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T. B. LITTLE, EDITOR

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WEDNESDAY EVENING
APRIL 24th, 1935

THURSDAY (all day)
APRIL 25th, 1935

TENTATIVE PROGRAM

WEDNESDAY EVENING, APRIL 24th

7:30 P. M.

"Maintenance of Roll Neck Bearings"

THURSDAY MORNING, APRIL 25th

9:30 A. M.

"Selection of Electrical Equipment for Direct Current Power Supply in Rolling Mills"

10:30 A. M.

"Metallurgical and Thermo-Dynamic Calculations as Applied to Heating Furnaces."

11:30 A. M.

"Soaking Pits"

THURSDAY AFTERNOON, APRIL 25th

1:30 P. M.

"Modern Rolling of Broad Strip Steel"

2:15 P. M.

"Improvements in Design and Operation of Open Hearth Furnaces"

3:30 P. M.

"Natural Gas in Steel Plants"

PROGRESS IN EMPLOYEES' REPRESENTATION

▲

A study of the February issue of the Bethlehem Review, a bulletin of news for the employees of the subsidiary companies of the Bethlehem Steel Corporation, cannot but help eliciting favorable comment for the manner in which this company has conducted its employee representation plan. Having the distinction of being one of the pioneers in American industry as one of the first companies of its kind to establish an agency of this type, the Bethlehem Corporation has done much toward bettering the social and industrial relations between the employee and employer.

That the principles of the plan of this company are constructive and useful cannot be denied when some of the outstanding facts are read. Pensions paid by Bethlehem Steel Corporation during the past 12 years have totaled $6,754,721. There are 1,896 retired employees on the pension rolls. The cash disbursements to employees or their beneficiaries under the relief plan during the past nine years have totaled $8,456,277. Participation in elections of representatives under employee representation plans in 1934 was 93,7%. In this same year 814 cases of record concerning hours, wages and working conditions were handled.

The meaning of these factual statements have been given voice by E. G. Grace, President of the Bethlehem Corporation, who. in prefacing this bulletin, says in part: "The position of our company today shows how mutual efforts protects our jobs. It is significant that Bethlehem's greatest development has taken place during the period that these plans have been in effect. New plants had to be built and old plants revamped. Products for manufacture had to be discriminately selected. New markets had to be opened up and sales contacts developed. An organization had to be developed and trained. In short, Bethlehem had to be converted from a small manufacturing concern to a nationally recognized leader in the industrial field. All have played their part, and Bethlehem stands as a monument to this joint relationship of employees and management, having become the second largest steel company in the world, a national concern of integrity and permanence. The attainment of these objectives has meant much to the employees, because in the sound progress of our company lies their best assurance of economic security."

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Automatic Control and Use of Fuels In Steel Mill Furnaces

By A. J. FISHER
Fuel Engineer, Bethlehem Steel Company,
Sparrows Point, Maryland

Paper presented before the Philadelphia District Section of the A. I. & S. E. E., December 1, 1934.

Iron has been known and used by man for at least 6,000 years. Explorers found it in the base of the great Gizeh Pyramid, and it probably was used in the construction of the pyramids.

Early attempts at iron making were very simple. Iron ore was reduced by charcoal. The ore melted and allowed the heavier metal to run off at the bottom. The bellows were made of two great skins, and two bellows were used, one discharging while the other filled.

In the eighth century, at Catalonia, Spain, the first great change in iron making was established. Here the Catalan Forge was developed. These forges were formed of stone and did not melt the iron, but rendered it in a plastic state, and by skillful working, the foreign particles were taken off the iron, and a required amount of carbon from the charcoal was worked into the iron. Some very fine steels were produced in these furnaces.

It was not until 1340, in Marche les Dames, Belgium, that the first blast furnace was originated. These early furnaces were built entirely of stone. Charcoal was used as a fuel with cold blast. The iron and slag were melted, thus producing cast iron.

During the eighteenth century, England was witnessing the fast depletion of its woods in the manufacture of charcoal for furnaces. Consequently, considerable effort was spent toward the use of coke in iron smelting. John Wilkinson built the first coke blast furnace near Wolverhampton, Stafford, England, in 1754; he was not the inventor but was the first one to establish its use.

The next milestone in the development of blast furnaces was marked by James Neilson in Scotland, who in 1828 accomplished the smelting of iron ore with the use of the hot blast. However, it was not until 1840, twelve years later, that America copied England's practice, and on July 4, of that year made the first iron by hot blast and anthracite coal. The place was a few miles above Allentown—and was later named Catasauqua.

The stone age in blast furnace construction came to a close in 1854, when, for the first time, at Port Henry, New York, a furnace was built completely incased in an iron shell.

For the past 100 years, there have been no basic changes in blast furnace practice, with the exception of improved mechanical appliances. Blowing engines have kept pace with the demands, the furnaces have been enlarged for greater capacity, the automatic skip hoist is a refinement, hot blast stoves have been made more efficient, and in whole or in part we have arrived at a giant piece of mechanism, which, to the ordinary layman, is quite enigmatic.

In our modern blast furnaces, we have such a multiplicity of metallurgical reactions revolving about temperatures, that it becomes like life itself,—the more one knows, the more there is to know. Naturally we are quite anxious to subject these furnaces to natural laws which in operation are so uncertain, incomprehensible, and capricious as to have earned universally the human pronoun "She".

One of the great mechanical improvements in blast furnace operation has just made its way over the horizon in recent years. It is the cleaning of blast furnace gas; the removing of fine particles of iron ore and coke from the gas. The purpose of this paper is to discuss the effect of this mechanical improvement to the steel industry and to the country at large.

Let us now examine conditions, relating to our subject, in the steel plant.

In times past most heating and melting furnaces were fired directly with coal or by coal producer gas. These two fuels, because of their physical limitations, are almost impossible to automatically control accurately in operation. They carry a considerable amount of free carbon when the necessary reducing

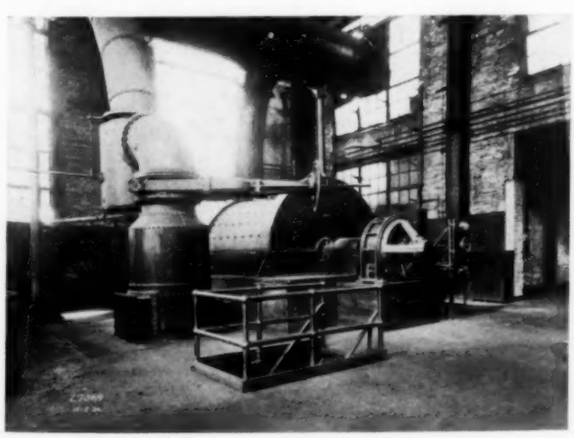

FIG. 1

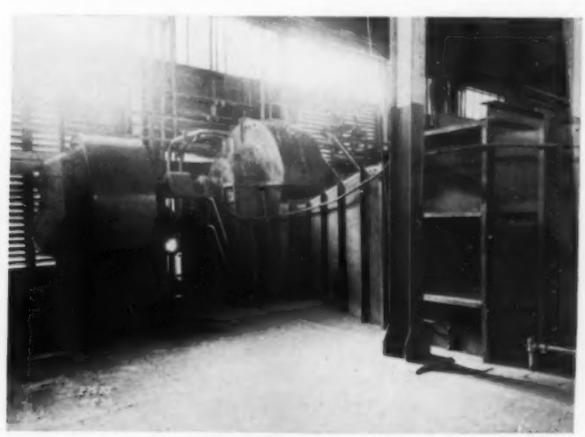

FIG. 2

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FIG. 1

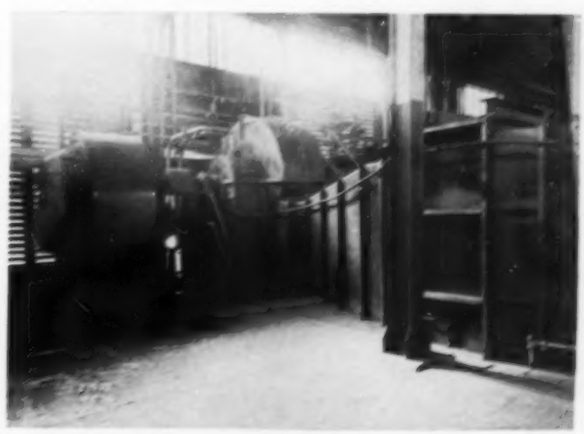


FIG. 2

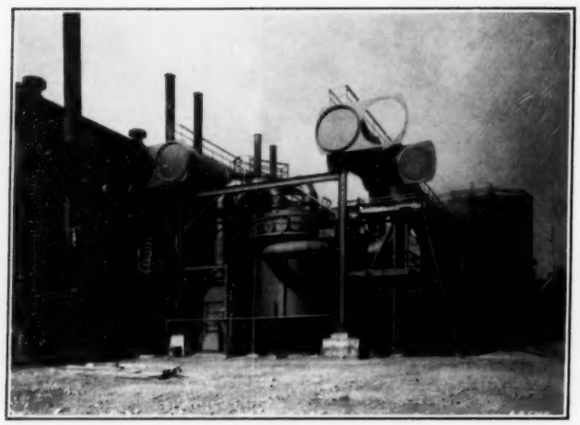


FIG. 3

atmospheres in the furnace are maintained, and consequently are dirty and smokey; and because of this dirt and smoke, these two fuels have created certain impressions about steel industry. Invariably the amount of smoke coming from a stack was used as a telltale to the speed of operations, and the men of the street have been indelibly impressed with the association of smoke and activity.

This smoke in steel mills has presented such a barrier that few people, indeed, have had the stamina to penetrate through it to the pulsing and vibrant romance of steel metallurgy and the steel forming processes.

At this point, I would like to quote Mr. Gerald W. Johnson in his article in Harpers Magazine for July, 1934, entitled "If There is a Maryland." In searching the state for reactions that might be called distinctly Maryland, he arrives at the plant in which I work in the following manner, "On the northern shore of the Patapsco River, just below Baltimore City, is an incredible forest of smokestacks, lying by day under a black pall of fumes, and illuminated by night by the lurid glow of hell itself, constituting the greatest steel manufacturing district on tide water; but that is not Maryland—God forbid!" Condensed it reads as follows, "smokestacks", "black pall of fumes", "hell itself", and "God forbid". By these words you have heard the general public's condensed description of a steel plant; a description which is fast becoming obsolete.

Due to the pressure of our present economic and industrial crisis, it has been necessary to adopt all possible economies, and to this end great strides are being made in all divisions of steel manufacturing. In fuels and furnaces two definite and distinct changes are taking place. On one hand, blast furnace and coke oven gas, both by-products, are being used to eliminate coal and coal producer gas in the mills, and on the other automatic control with proper furnace design is insuring maximum efficiency of the substituted fuels; which is made possible by their cleanliness and ease of accurate measurement. It is not uncommon to expect a reduction in fuel input of 30 to 50% in the substitution of automatically controlled gas fired fuels for coal and producer gas. The metallurgical operation is invariably improved, and furnace repair costs are lowered.

In this transformation the outward appearance of the plant changes most. The stacks become perfectly clear and to the casual observer operation and no operation appear to be one and the same.

Blast furnace gas was used to preheat the blast, underfire boilers and was also bled to atmosphere, in the dirty and semi-cleaned state, since 1828 until comparatively recent times. It was a low grade of fuel, could not be transported far, or accurately measured. Flue dust accumulated in the lines and had to be shovelled out periodically. Due to the various flushing holes and drains necessary in the lines, considerable leakage occurred. The poisonous monoxide fumes were dangerous, and no one cared to become too familiar with blast furnace gas, much less be concerned about its conservation.

These conditions, just recited, were complementary with gas cleaned from the old water tower washers. The gas was, of course, saturated, carried considerable entrained moisture, and contained approximately 0.40 grains of flue dust per cu. ft. of gas.

The change of caste of blast furnace gas from a low grade fuel to a high grade fuel was concurrent with the development of adequate cleaning equipment that reduced the grains of flue dust per cu. ft. of gas from 0.40 to 0.014 and less. This is cleaner than the air we breathe in most cities. By the addition of suitable entrained moisture eliminators and pressure boosters blast furnace gas can be transported and used in much the same manner as city gas is used.

With clean blast furnace gas the set up changes, in that the gas is used in the stoves, and in the plant replacing coal. The coal or oil is then used in the boilers. This trading of fuel appears to be foolish when one considers that capital investment is required to make the change, and that a B.T.U. of coal is the same as a B.T.U. of gas. However, coal can be powdered and used in the boilers, the con-

COST PER 100,000 CU. FT. BLAST FURNACE GAS CLEANED

	Water	Power	Steam	Repairs Labor Misc.	Total Cost	Installation Cost Per 100,000 Cu. Ft. per Minute Complete Including Moisture Eliminators But Not Including Boosters and Spare Capacity.
Drum Theisen	$.00916	$.0684	None	$.03203	$.1096	$160,000.00
Disintegrator Theisen	$.00617	$.0431	None	$.02313	$.0724	$105,000.00
Cottrell	$.00199	$.00474	$.00099	$.009535	$.0172	$125,000.00

Power at $5.68 per 1,000 K.W.
Water at $0.0136 per 1,000 Gallons.

FIG. 4

trol is accurate, maintenance and operating costs are lower, and the heat efficiency is improved. This improvement is slight; approximately 3%. In the mills, blast furnace gas is controlled, furnace maintenance is reduced 50 to 70%, fuel B.T.U. input is reduced 30 to 50%, and a general improvement in heating results; namely, the flame temperature is low and the loss due to burned steel is practically eliminated, thus insuring good even heating, scaling is reduced because of the reduction of hydrogen in the fuel, and air infiltration is reduced due to the increase in the volume of the products of combustion which tend to increase furnace pressures.

By this method the boilers take the place of a gas holder in maintaining constant gas pressures by means of automatic auxiliary firing, and as a large potential user of gas eliminating the necessity for much bleeding of gas to atmosphere at times when the mills are not operating.

Three types of gas cleaning equipment have been evolved. The Drum Type Theisen, Figure 1, was the first to be generally accepted, then the Disintegrator Theisen, Figure 2, and the Cottrell Electrical Precipitator, Figure 3. All three types clean the gas to acceptable cleanliness, however, their apparent costs are dis-similar. The factors common to all three making up their major operating costs are water and power. Figure 4 gives the probable comparative operating costs at one plant without the use of spare capacity.

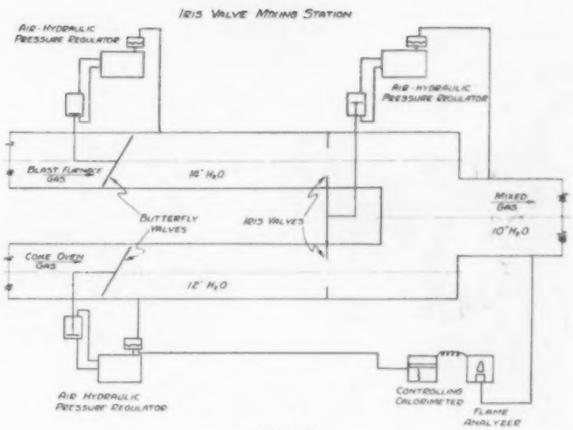


FIG. 5

There are five methods or combinations in common practice of using blast furnace gas:

1. Blast furnace gas and cold air.
2. Blast furnace gas and hot air.
3. Hot blast furnace gas and hot air.
4. Mixed blast furnace and coke oven gas, and cold air.

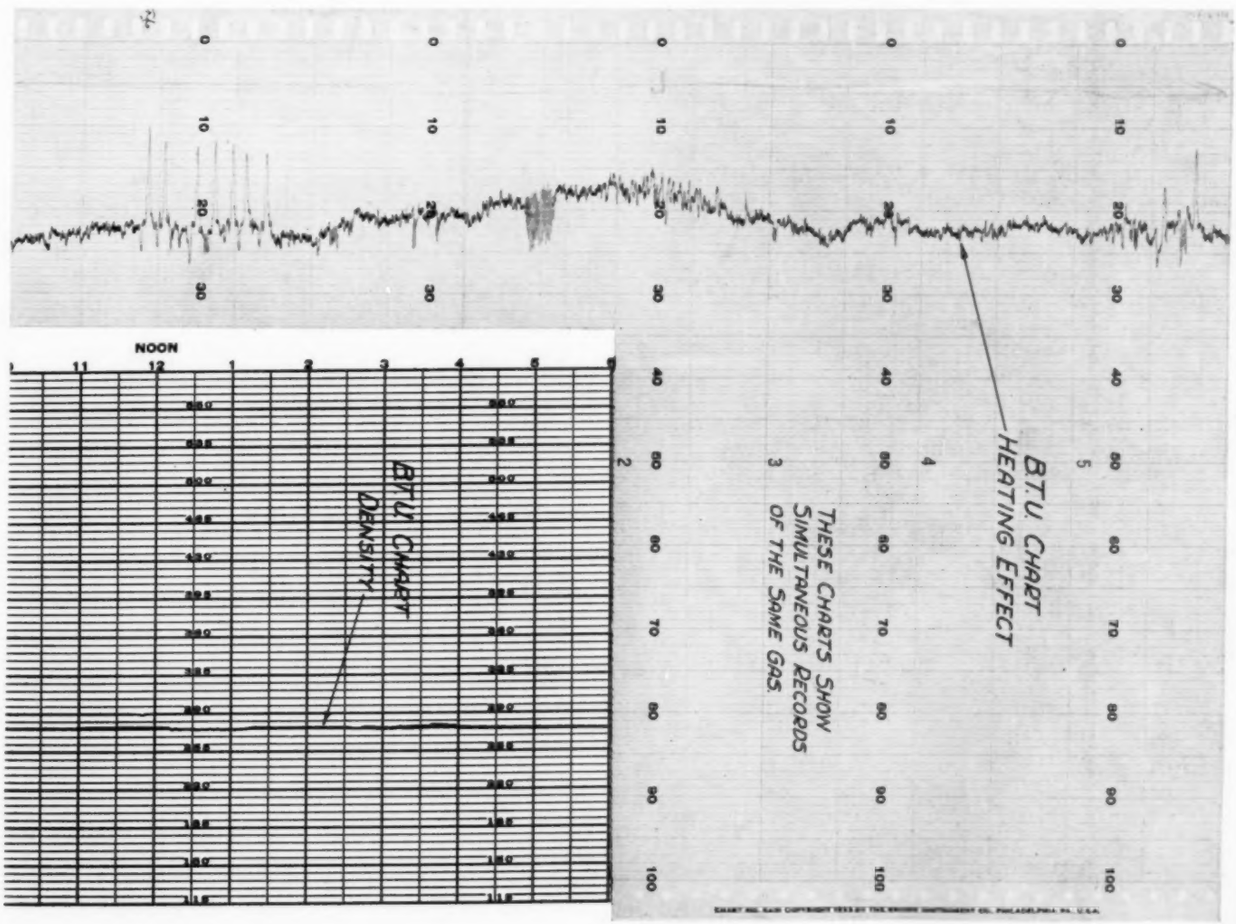
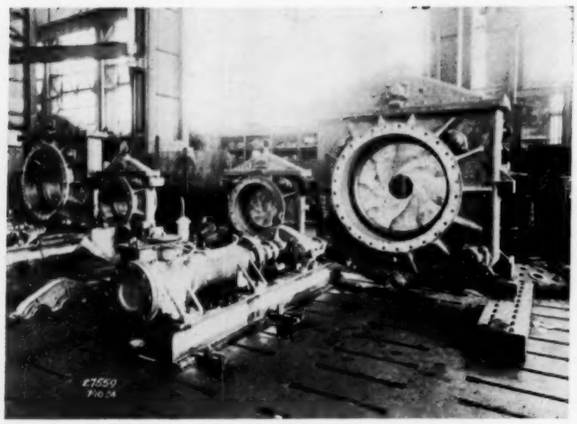


FIG. 6



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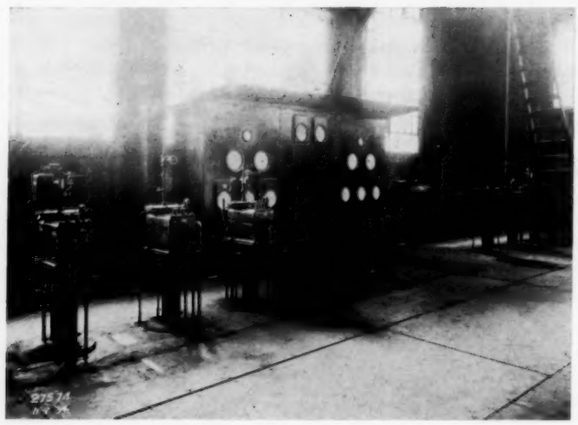

FIG 9

5. Mixed blast furnace and coke oven gas, and hot air.

The use of any of these methods depends largely upon the flame temperature desired. Pumping or boosting costs, size and length of line, etc., are of secondary importance.

Blast furnace and coke oven gas are best mixed by the iris valve mixing station, particularly is this true if no gas holders are used after mixing. A diagramatic layout of the iris valve mixing station is shown on Figure 5. The station employs the use of three pressure regulators, two iris valves, two butterfly valves and one calorimeter. The pressure regulators and valves are so designed to give accurate volumetric mixing, while the calorimeter control changes the loading on one of the butterfly valve regulators in order to give the required heat values. The station is particularly adapted to handling variable loads with accuracy.

The calorimeter control may take either of three forms:

1. Control from gas density.
2. Control from B.T.U. per cu. ft.
3. Control from heating effect or combination of density and B.T.U. per cu. ft.

The latter appears to be the best type as the gas is analyzed and controlled in exactly the same manner in which the furnaces use it. Figure 6 shows two simultaneous density and heating effect charts on mixed blast furnace and coke oven gas.

Figure 7 shows the construction of the iris valves. Figure 8 shows the valve layout, and Figure 9 shows the regulators and instruments of a blast furnace and coke oven gas mixing station. Figure 10 shows the flame temperatures of mixed blast furnace and coke oven gas with cold air.

Figure 11 shows the quantities of gas produced from four blast furnaces making 1000 tons of pig iron per day with a coke ratio of 0.85%.

The analysis of blast furnace gas is shown in Figure 12.

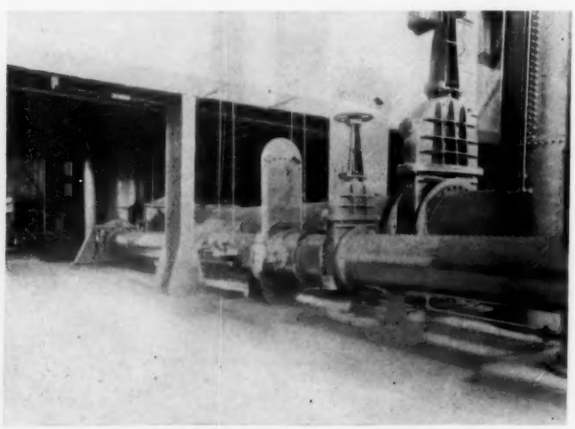

FIG. 8

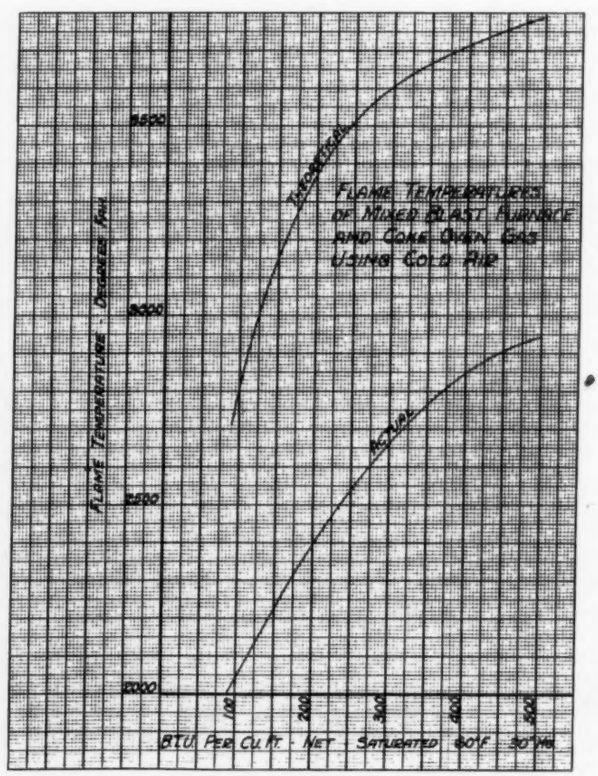

FIG. 10

QUANTITIES OF GAS FROM FOUR BLAST FURNACES
85 COKE RATIO, 1,000 TONS PIG IRON PER DAY
70 CU. FT. GAS PER LB. COKE
COKE 85% CARBON

QUANTITIES PER DAY—EQUIVALENT BTU

Cu. Ft. 100 BTU Gas	Tons Coal	Gallons Oil	Cu. Ft. 500 BTU City Gas
533,120,000	1,763	350,724	106,620,000

35 CARLOADS GAS FOR CITY OF 2,500,000 POPULATION (Average Flow)

FIG. 11

The flame temperatures of blast furnace gas with preheated air are shown in Figure 13.

Having noted some of the general points of interest, let us draw a little closer and examine a few of the special cases where the use of cleaned blast furnace gas has played an important role.

The first great change is in the blast furnace itself, by means of higher blast temperatures due to more efficient stoves, made possible by clean gas. With dirty gas, the stove checkers had to have large openings to keep them from plugging up. This plugging increased stove maintenance cost. Now with clean gas, the openings in the checkers can be made smaller and the height of the stoves increased for longer travel of the gases, and a fixed and constant amount of gas can be burned at all times since the checkers stay open and do not offer greater resistance as in the case of dirty gas. All in all, the air preheat to the furnace has been increased from 1000° F. average to 1350° F., and in some cases 1500° F., average blast temperature has been maintained.

This increase of 350° to 500° F. in blast temperature is not very impressive until we examine the metallurgical reactions in the blast furnace. Figure 14 gives the graphical reactions, and when they occur in the furnace. Note that practically all the general chemical changes have taken place above the temperature of 1472° F., and from this point on down, it becomes a matter of getting the mass in the molten state; or directly a function of flame temperature. If we say that 2750° F. is the critical melting temperature, it is obvious that no melting occurs with flame temperatures below this figure, and accordingly we are concerned only with temperatures above this point. Figure 15 shows the relative flame temperature in the blast furnace. If 2750° F. is considered the base line of activity, it is then very obvious that an increase of air preheat from 1000° to 1500° is very important, so much so in fact, that the coke input to the furnace can be reduced about 20% of its former quantity if the higher air preheat is used. This has a direct bearing on the amount of blast furnace gas made, since one pound of dry coke containing 85% carbon makes 70 cubic feet of dry gas in which the summation of the carbon gases equal 38.5%.

Cold gas and air are used in the heating of the checker work in the blast furnace stoves.

Control on the blast furnace stoves should consist of a hydraulic pressure regulator and butterfly valve in the main to the stoves to one furnace. The regulator should have a safety device attached in which the butterfly valve will close when the gas pressure approaches zero, and an alarm should be sounded at the same time. The control should be so constructed that it will not open upon the return of the gas pressure, but will have to be placed in operation by the stove tender after he has made the necessary adjustments to the gas burners.

BLAST FURNACE GAS ANALYSIS

	PER CENT
CO_2	10.7
CO	27.9
H_2	1.5
CH_4	0.2
N_2	56.8
H_2O	2.9
BTU per cu. ft., wet basis—net Saturated at 60° F and 30" Hg=94.3	100.00

FIG. 12

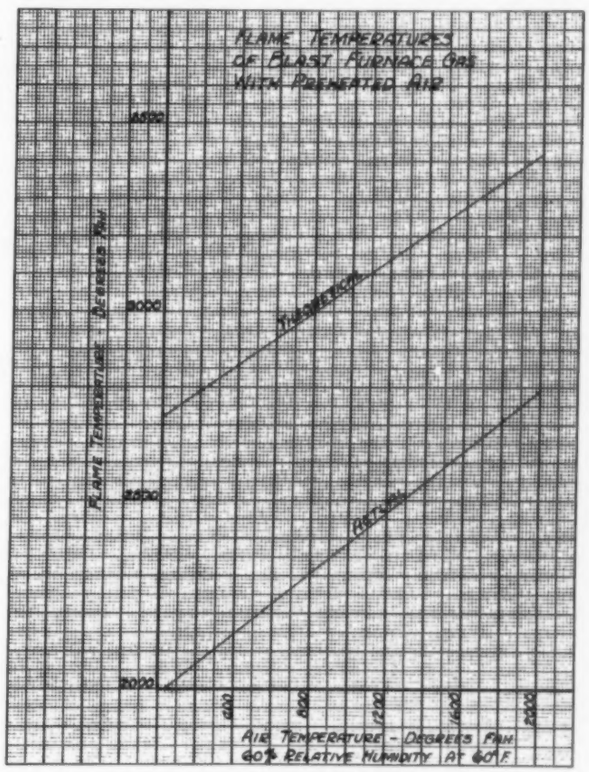

FIG. 13

The blast furnace gas driven blowing engines are best equipped with a master pressure regulator and a heating effect calorimeter control to vary the controlled gas pressure. The type of control enables the air-gas adjustments to the engines to remain constant under most normal changes in gas analysis and insures maximum efficiency.

Blast furnace gas is used to underfire coke ovens. Here the combination of hot gas and hot air is used for maximum flame temperature. Each coke oven battery should have its own pressure and safety regulator of the hydraulic type. The use of blast furnace gas for underfiring coke ovens enables 100% instead of 60% of the coke oven gas made, to be used for uses outside of the coke oven operation.

One of the best applications of straight blast fur-

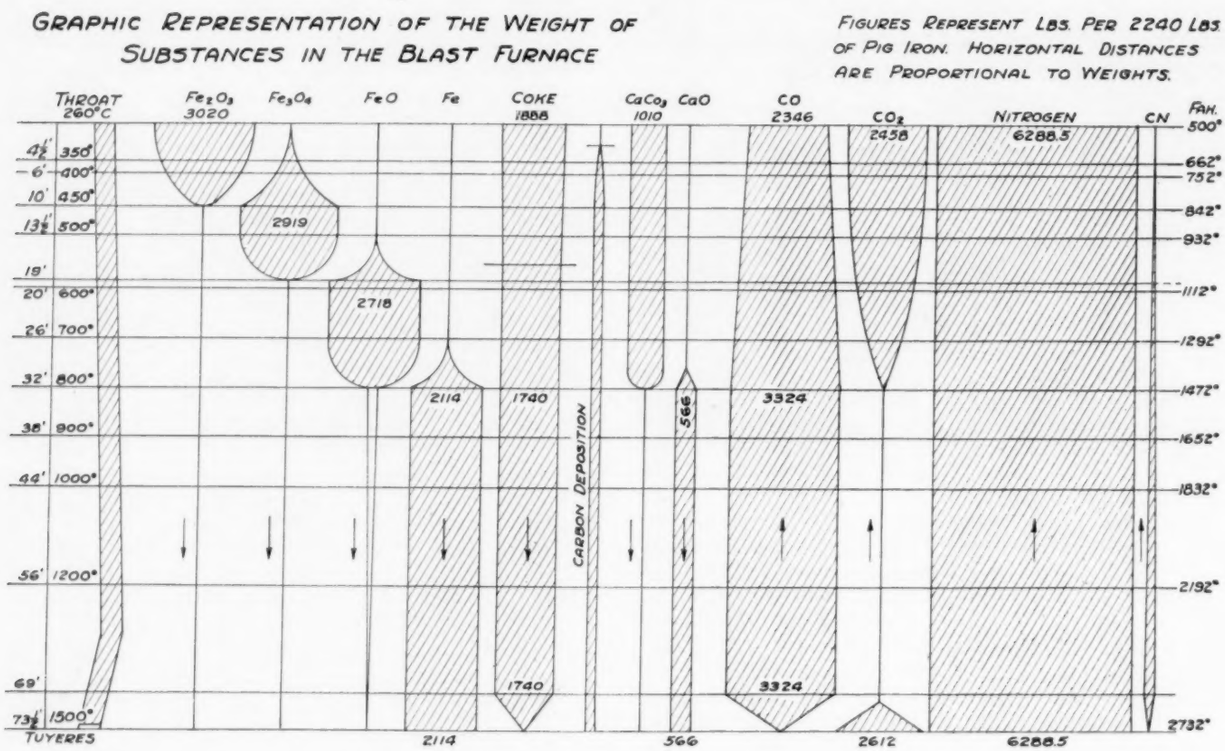

FIG. 14

nace gas in furnace work is the soaking pit for heating ingots. Here the combination of cold blast

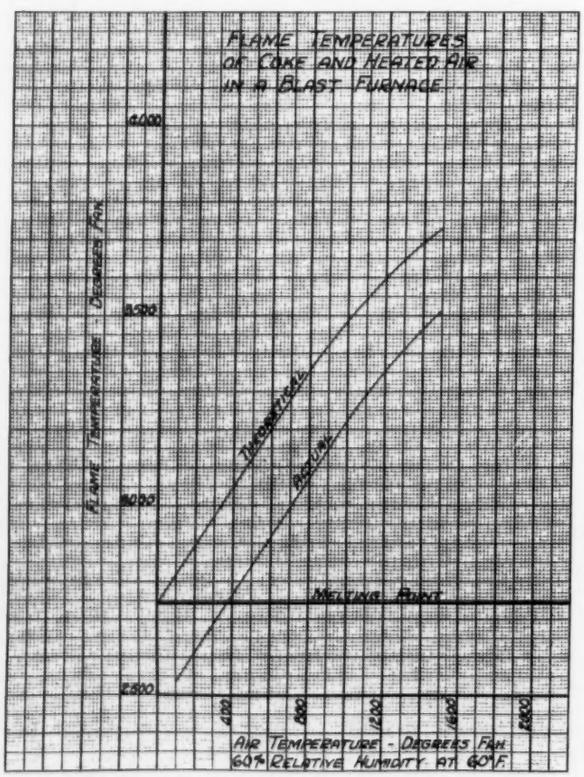

FIG. 15

SOAKING PITS

BLAST FURNACE GAS AIR PREHEAT 1660 DEGS. F
MAXIMUM INGOT TEMPERATURE 2300 DEGS. F

Size of Ingot Inches	Pounds per Ingot	No. Ingots Charged Each Pit	Charged Cold	TIME HOURS Charged 400 to 500 degs. F	Charged 1000 to 1200 degs. F.
20x24	6000	6	6	3.5	2.5
22x24	7000		7	4	
23x28 24x29 25x30	14000	6	8	4 to 5	2.5 to 3.5
28x40	20000	4	8 to 9	5.5 to 6	3 to 3.5
25x50 26x50	25000 to 26000	4	8 to 9	5.5 to 6	3 to 3.5
31x50 32x50 32x50	28000 to 30000	3	10	6	3 to 3.5

On these pits the bottoms are made every 12 days and during this time they are sprinkled with coke to freshen them up every third day.

On the old pits using gas producer gas, bottoms must be made every third day.

FIG. 16

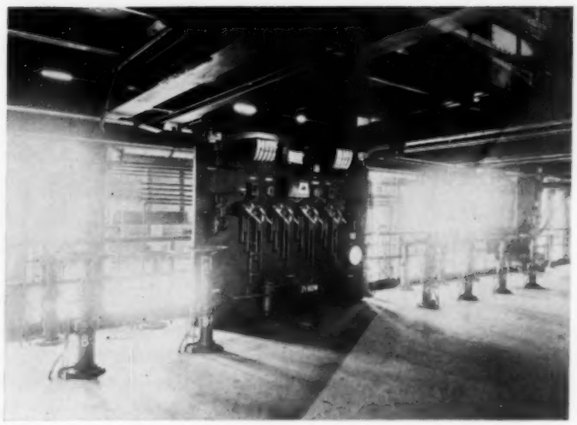

FIG. 17

furnace gas and heated air are used to give a flame temperature slightly higher than the rolling temperature required. By use of high velocities, automatic reverse and fuel-air relations, remarkable results are obtained. Figure 16 shows the performance of a blast furnace gas fired pit. Figure 17 gives the control board and Figure 18 shows the gas lines applied directly above the checker work. The soaking pits should be equipped with a combination pressure and safety regulator with manual reset. In addition to closing the master butterfly valve, the individual valves should also be closed, on gas failure, power failure, and failure of the forced draft.

In reheating furnaces of large sizes, in close proximity to the blast furnaces, it is desirable to have a gas mixer at each furnace. Here a gas of the required flame temperature can be mixed for the most efficient results, at low pressures of approximately 15" H_2O or less.

For general work of all classes of furnaces both large and small, a central mixing and ten pound boosting station is most desirable. A gas of 300 to 320 B.T.U. per cubic foot seems ideal for general purposes. The flame temperature for a gas of 300 B.T.U. with preheated air is shown in Figure 19.

Complete combustion control, automatic furnace pressure, and automatic reverse are essential on all large furnaces.

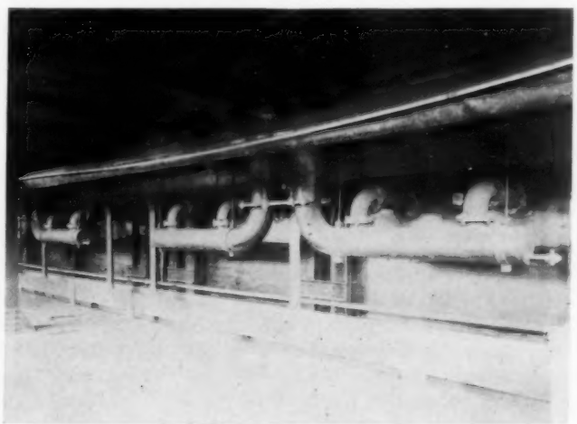

FIG. 18

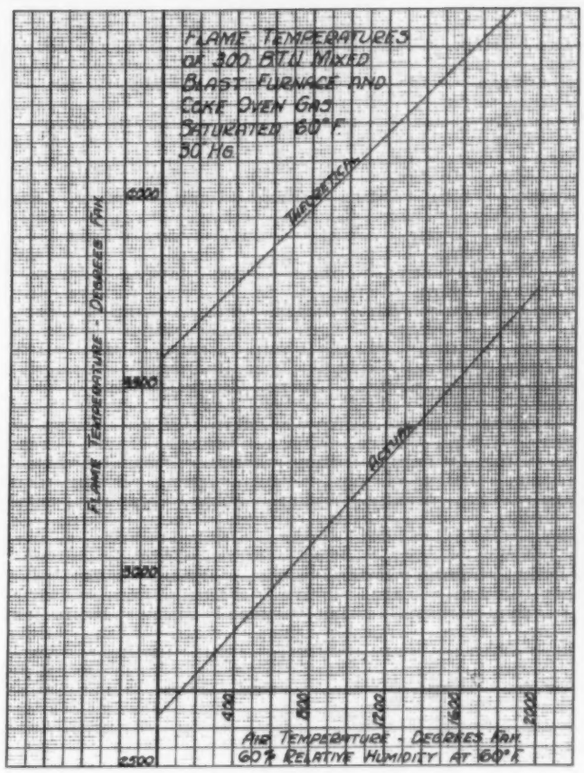
FLAME TEMPERATURES OF 300 BTU MIXED BLAST FURNACE AND COKE OVEN GAS SATURATED 60°F 30 HG
FLAME TEMPERATURE - DEGREES FAHR
3200
3000
2800
AIR TEMPERATURE - DEGREES FAHR
60% RELATIVE HUMIDITY AT 60°F

FIG. 19

Every large operation or group of small operations should have a meter. It is always a good thing to post daily fuel rates per ton of product, as it shows the difference between poor and good operations and the relative costs. Furthermore, it leads to interest in fuel economy.

A list of applications for 300 B.T.U. gas includes:

1. Bessemer bottom-drying ovens.
2. Core drying and stopper ovens.
3. Hot metal mixers.
4. Soaking pits.
5. Reheating furnaces, continuous and regenerative.
6. Sheet and pair furnaces.

FIG. 20

7. Continuous and batch type box annealing furnaces.
8. Sheet normalizing and annealing furnaces.
9. Tinning and galvanizing pots.
10. Tin scruff furnaces.
11. Deoxidizing sheets.
12. Hot mill roll warmers.
13. Air heaters and small steam boilers.
14. Paint drying.
15. Laboratory Bunsen burners.
16. Babbitt pots, etc.
17. All types of forge, angle, and riveting furnaces.

Figure 20 shows 300 B.T.U. gas applied to a sheet normalizer with air inspirating type burners. Figure 21 shows a similar furnace on sheet packs.

Blast furnace gas-electric engines are large consumers of gas. These engines should be equipped with pressure and calorimeter control similar to that described under blast furnace gas blowing engines.

The steam boilers are of particular interest to the blast furnace gas problem. Interest lies in the fact that gas holders are not practical for blast furnace gas. A 10,000,000 cubic foot holder could be filled in 27 minutes by four blast furnaces operating. This

FIG. 21

short time makes the capital expenditure of suitable gas holding capacity very unattractive. Therefore, it is necessary to equip the boilers to burn blast furnace gas and an auxiliary fuel such as coal or oil in plants where the demands for gas in the mills is lower than the production. In this manner practically all the blast furnace gas can be used, except at week-ends. On the other hand, if the production of blast furnace gas is not enough, it is possible to add to it by the use of coke gas producers. These producers, by use of automatic pressure control, can augment the blast furnace gas to any degree necessary. However, when producers are on, all the gas should be taken off the boilers and auxiliary fuel used entirely.

There is always a certain loss and unaccounted for amount of gas in the operation of the plant, based on 70 cubic feet of gas per pound of dry coke. In a well regulated plant, this should not exceed 3%. This loss is composed mostly of top leakage. Another loss amounting to approximately 3% is bleeding during week-ends when the mills division of the

BLAST FURNACE GAS DISTRIBUTION

		PER CENT	PER CENT
1.	BLAST FURNACE AUXILIARIES		
	a. Blast Furnace Stoves	23.0	
	b. Gas Blowing Engines	10.0	
	c. Coke Oven Underfiring	16.0	
	d. Leakage at Furnace Tops, Lines, etc	3.0	52.0
2.	METALLURGICAL FURNACES		20.0
3.	GAS ELECTRIC ENGINES		10.0
4.	BOILERS (POWER & PLANT STEAM)		15.0
5.	BLED TO ATMOSPHERE		3.0
			100.0

FIG. 22

steel plant are down. Figure 22 shows a representative blast furnace gas balance of a steel plant.

Blast furnace gas commands a great amount of respect, because it is easily explosive, that is one volume of air to one volume of gas gives the explosive mixture. Therefore, when a number of users are set up operating from a blast furnace gas system, it is imperative that the positive displacement users do not pull a suction on the lines, thus drawing air in at some point of consumption, and blowing the system up when a static spark or ignition temperature occurs. Many ugly explosions have occurred from this source. For these reasons, it is essential to have a combustion pressure and safety regulator at each point of consumption. The closing point on the safety regulator is set to close each operation down as gas pressure fails according to preferential rating. For this purpose, we chose the air-hydraulic regulator because a receiver and check valve may be used in which the regulator can operate during power failure.

Discussion

Discussion presented by

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W. Goehring, Vice President, Automatic Temperature Control Co., Inc., Philadelphia, Pa.

P. C. Reichard: The author certainly has very ably presented the picture of the important sphere of fuel utilization and controlled distribution in the modern steel plant.

Prior to 1920 this phase of operation and service received little emphasis in the industry. Today, more than ever before the economical production of the finished product still remains the prime object and purpose of the business.

The "Distribution and Use of Fuels" although only secondary, represents such a large item in the

cost of the product due to the many metallurgical processes and operations in present day tailor-made specification steel mill; that a much greater importance and emphasis is attached by management to this phase of supply and service than heretofore.

The "Ultimate Purpose in Fuel Economy" in the steel plant means briefly—the elimination of the purchases of outside fuels, wherever possible and practical, and the sale of excess power, steam and by-product gas to utilities and other outside agencies.

In the Bethlehem Plant, eighteen years ago, this economy started with the substitution of coke oven gas for producer gas in large forge furnaces. Ten years ago one of these furnaces was redesigned for the use of a 250 B.T.U. mixed gas and in 1927, when straight blast furnace gas was applied to soaking pits, it was learned that this same metallurgical operation with slight changes in furnace design could be fired better with 100 B.T.U. blast furnace gas than with the 500 B.T.U. oven gas.

The very interesting romance as Mr. Fisher terms it, of the refinement and extension of the use and control of blast furnace gas in this country is really a quite recent development; and great strides have been made along this line during the past six years.

In Fig. 11, of subject paper the vast potential 40 per cent of blast furnace gas yield represents a possible 14% plant fuel economy. Fig. 22 represents the distribution story for one plant only with its own specific rate of operations and metallurgical and power load.

The real job of the combustion organization is the maximum useful distribution and most economical utilization of this 40% potential fuel block under widely varying rates of plant operation with the one and same purpose always in mind: the minimum outside purchases of power, coal, and fuel oil, and the maximum send-out of power and oven gas.

In venturing forth in the extension of the use of blast furnace gas, the most costly item encountered is that of gas line extensions and installation of modern cleaning devices; the advantages in favor of the installation of proper gas cleaning equipment are proven by the operating cost figures presented, and the attendant widened range of efficiency of metallurgical application, and lowered costs in engine maintenance.

Without automatic control devices, installed for purposes of safety, pressure and volume control; the far flung substitution of blast furnace gas, as a straight or a mixed fuel to the many varied metallurgical applications would have been practically impossible.

Gas mixing in the Bethlehem Plant was started eight years ago, and during the past six years we have applied low B.T.U. mixed gas to open hearth, forge, reheating, and treatment furnaces with remarkable success. During the past four years all the consuming units of departments listed above have experienced very satisfactory results utilizing pressure controlled and metered straight blast furnace gas.

The iris valve, B.T.U. controlled gas mixer described is the ultimate ideal device for this automatic purpose, from the standpoint of adaptability and range adjustment to widely varying rates of flows and precision in control of the B.T.U. value of the mix.

The Sparrows Point layout no doubt adapts itself to the highly developed type of gas mixing plant described.

In our Bethlehem Plant with metallurgical operations of a somewhat different nature than those at The Point, experiment and experience have proven the practicability of utilizing 90% of the excess blast furnace gas straight; the only exceptions being in the soaking pit where pressure controlled blast furnace and oven gas are hand mixed by means of graduated valves, using meters to guide B.T.U. and volumes; and there only, when heating cold steel. Our pits have been rebuilt on the basis of economical use of either a 100 or 160 B.T.U. gas.

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With the far flung extension of plate sheathing and the application of insulation to furnaces, automatic pyrometric roof temperature controls have been extended to open hearth and heating furnaces. Automatic three-way: time, temperature or manual reversing equipment has been successfully installed on open hearths, and the most practical operatives in the field call for this feature on all operating units. These devices, although on first inspection appearing intricate and costly, offer relatively no operating hazards and effect economies in refractory life extensions which pay for themselves in a short period of time.

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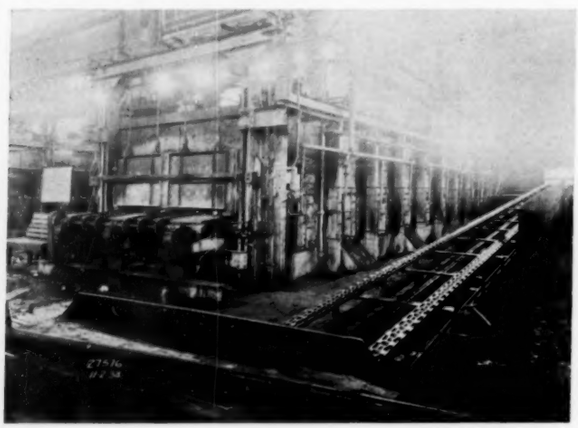

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Seibert in 1923, describing the progress that had been made in the use of blast furnace gas at the plant where Mr. Fisher is now employed and has carried on the good work so well started.

I remember visiting Sparrows Point with Mr. Seibert shortly after he presented his paper, and among other things, inspecting two rail mill furnaces operating on a mixture of coke oven and blast furnace gas, then the combination gas heat value was 350 B.T.U. per cu. ft.

Since that time, regulators and control equipment have greatly improved until instead of hunting for or developing suitable equipment we now have a choice of competitive equipment.

I concur with Mr. Fisher, regarding the usefulness of the iris shutter as a controllable variable orifice for the mixing of gases within reasonable pressure ranges and temperature limits, and its use is becoming increasingly popular for the control of combustion air in conjunction with liquid fuel. In common with many other regulating devices, the iris shutter must be protected by handling clean gases only.

W. Goehring: I join in congratulating Mr. Fisher on a most excellent, instructive and thoroughly prepared presentation of a subject of paramount importance in steel mill operation, "The Automatic Control and Use of Blast Furnace Gas in Steel Mill Furnaces."

The details to which Mr. Fisher has gone in presenting statements and facts should prove of value to others of similar interests.

The company with which I am associated has been privileged to furnish for steel mill automatic control applications both time cycle contactors or time metering devices and automatic temperature fuel valve motor mechanism regulators, the latter functioning from temperature measuring instruments of the indicating or recording controlling type. It has been pleasing to learn from Mr. Fisher's presentation here tonight that the application of automatic control, through instrumentation of the various processes, has materially aided in obtaining economic results shown.

In the review of Mr. Fisher's paper it is gratifying to hear that Mr. Reichard remarked to this effect—"that even the most hard boiled operators, when once they have been given automatic control, whether on automatic reversal of fuel to soaking pits or other automatic control, they insisted on its being retained," because I know we, who are engaged in developing and supplying automatic control, have sometimes wondered how the plant crews look upon the invasion of automatically doing what may be considered the human prerogative of industrial production.

Thank you for allowing me to make these few remarks and I feel sure that all here tonight have enjoyed this evening's enlightening association.

ILLINOIS STEEL COMPANY PROMOTIONS

W. S. HALL

W. S. Hall, formerly chief engineer of the Illinois Steel Company, South Chicago Plant, has been made assistant general superintendent of that plant. Mr. Hall, an active member of the association, is a past president of the society and at the present time is serving as the treasurer.

Another change at the South Works of the Illinois Company is that of C. J. Smith being advanced from the superintendency of the electrical department to the head of the auxiliary departments among which includes the mechanical, transportation and electrical. Mr. Smith is also an active member of the association representing the Chicago section as chairman this year.

To succeed the late G. T. Hollett, who was the fuel engineer, E. O. Harmon has been appointed.

C. J. SMITH

Use of Automatic Control On Metallurgical Furnaces

By A. J. BOYNTON
Vice President of H. A. Brassert & Company, Chicago, Ill.

Paper presented at the A. I. & S. E. E. Annual Convention held in Cleveland, Ohio, September 18, 19 and 20, 1934.

No one has ever seriously questioned the desirability of maintaining in a metallurgical furnace an ideal set of conditions with regard to fuel supply, size and shape of flame, rate of exit gas flow and composition of atmosphere. It is probable, however, that in the absence of thorough and general experience, the full measure of possible benefits arising from such a set of regulated conditions is seriously underestimated by many metallurgical engineers.

This lack of adequate experience arises from three causes, the first of which has been the presence of defects in the design and construction of the furnace itself, and the second, the former inability on the part of makers of regulating equipment to provide control facilities which met the demand for accuracy, and which were at the same time reliable and thoroughly practical. The third difficulty arose from the fact that melters and heaters had very generally been trained in a school in which practice was based on the eye and on the overall results arising from a method developed by experience. These men, while well trained in their own methods were not prepared to accept and to apply practices based on the physical sciences, even though these methods had been worked

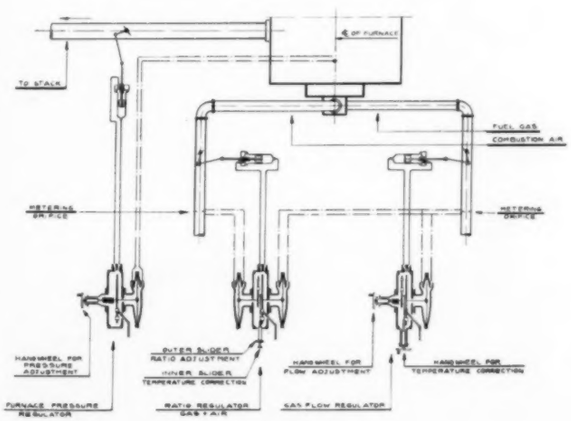

FIG 1.

out better than they actually were. Development and progressive change were, therefore, necessary with regard to all three of these factors before the objects of automatic control could be successfully attained.

Within the past few years rapid changes have taken place. Furnace proportions and methods of construction have been improved so as to give a much better contact between heating gases and the work. New burners, changed both in design and location, assist in determining the size, shape and direction of the flame. Insulation has prevented heat losses, while at the same time making the furnace substantially air tight against the existing differences in pressure.

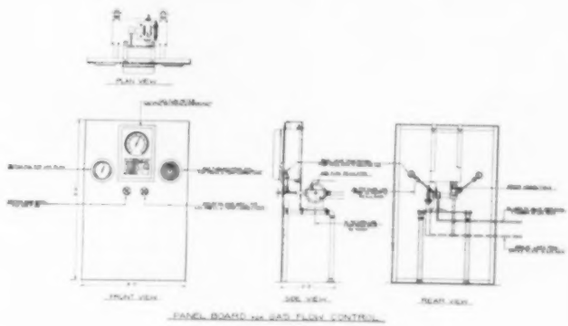

FIG. 2.

On the personnel side, much has been accomplished, both by selection and by education. The use of instruments for indicating, recording and controlling has become in some degree familiar to all operators. Technical supervision by a skilled engineer is practically universal. Understanding by the crews of the physical and chemical laws underlying the processes which require to be controlled is less complete than it should be, and, this lack of understanding forms a practical limitation to the

FIG. 3.

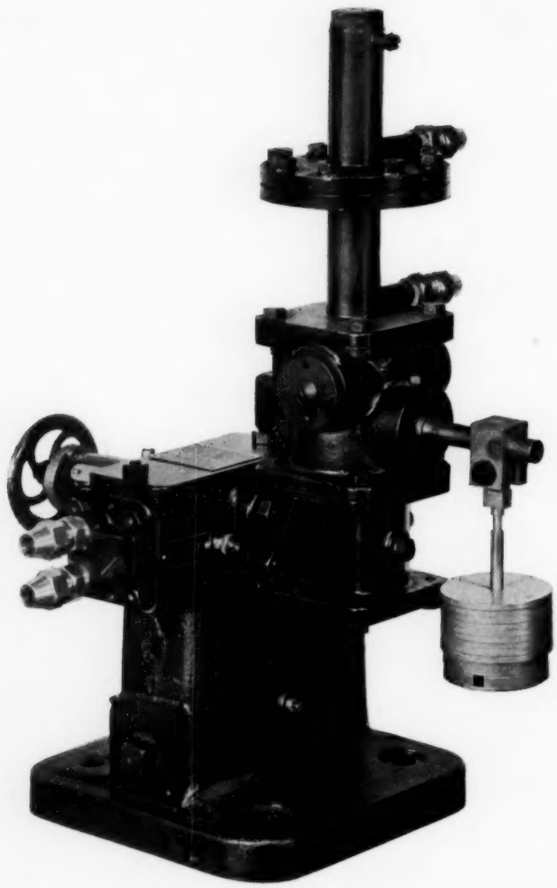

FIG. 4.

complexity of control systems which may be advantageously applied.

Noteworthy advance has also been made in the design and practical application of methods and equipment for control. A discussion of the present status of these methods and equipment makes up the greater part of this paper. Before proceeding with this discussion it seems well to point out certain facts which should be borne in mind in estimating the value of regulating processes. Attempts are always made to determine the results in the steel producing operation of the presence and use of regulating equipment. While it may seem unnecessary to point out so obvious a fact, it seems to me worth while to say that there is no set or predetermined value which can be assigned to any regulating act, excepting after consideration of its environment and the skill of its application.

Regulation at the best does not determine conditions, on the contrary it stabilizes and maintains them after they have been determined in accordance with the judgment of the operator. For example, the pressure in a metallurgical furnace may be carried high or low by the same regulator in the same operation in accordance with the preference of different operators. Presumably one of these operators is wrong or at least less correct than the other. The regulator may be supposed to be discharging its function with equal accuracy in either case but with varying results as to value of performance. If an operating staff has no particular conviction as to the regulated values the results may be expected to be indifferent. If, on the other hand, the object which is proposed to be accomplished is definite and based on correct considerations of practice the results are certain to be noteworthy and valuable.

Another consideration which I believe should be stated at the beginning is the high value in metallurgical work of completely automatic functioning by the control units. No metallurgical control is as yet completely automatic in all its phases; there is, however, a notable difference between the conditions of metallurgical work and those of steam boiler operation or oil refining, for example. In the latter cases

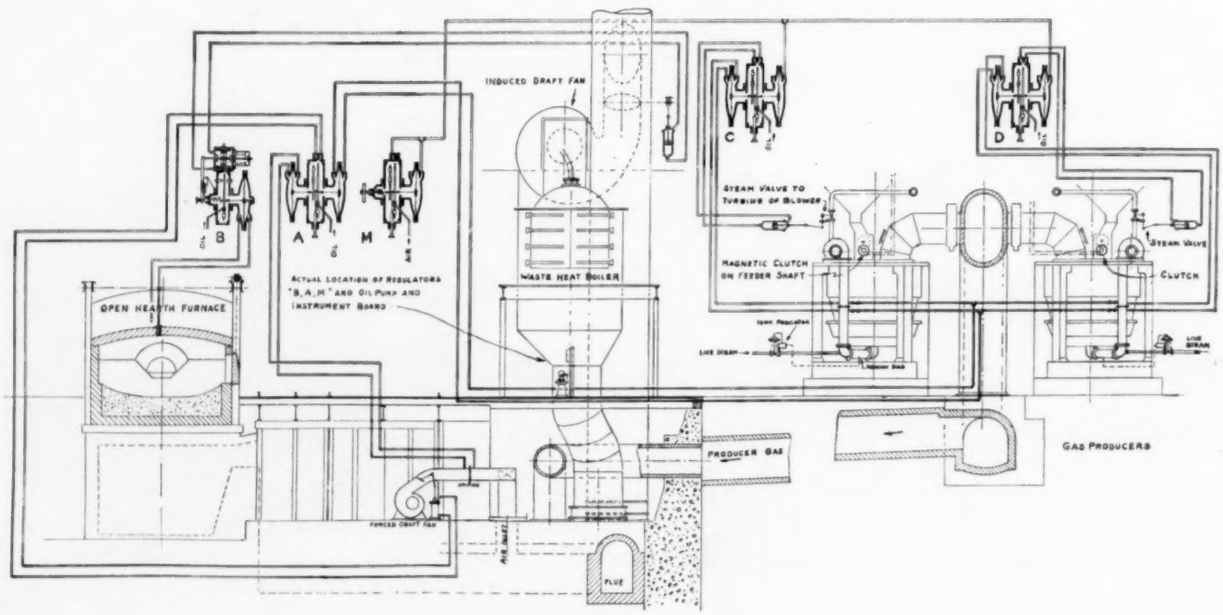

FIG. 5.

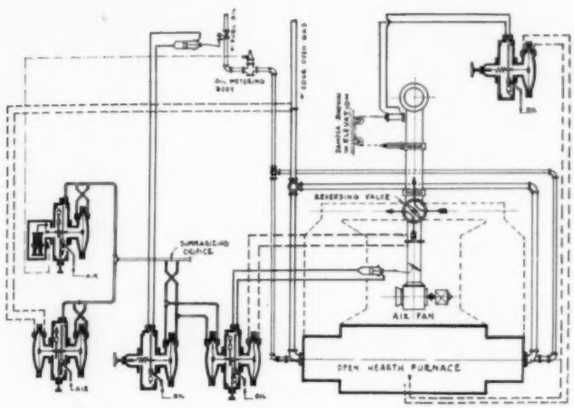

FIG. 6.

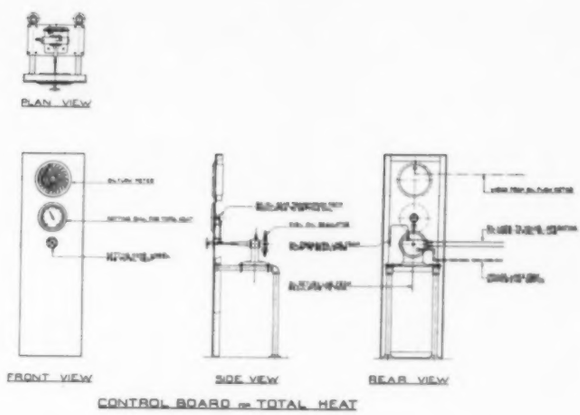

FIG. 8.

the process is continuous and relatively simple, and the regulated quantities determine in large measure the results of the operation. In metallurgical work the supplying and burning of fuel is merely incidental to other processes, many of them complicated and at times requiring the concentrated attention of the crew. Such semi-automatic systems of regulation as have been found to be useful and practical in steam generation are less so in metallurgical work. Furnace controls should, therefore, as nearly as possible, require the operator's attention only as the regulated condition requires to be changed.

Phases of Control

There are many aspects of control as applied to metallurgical furnaces, and a variety of problems to which it may profitably be directed. Some of these have to do with circumstances which require intermittent attention, as furnace reversal, some apply to the avoidance of an undesirable condition, as that of excess heating of roofs, while still others apply to the continuous circumstances of fuel flow, combustion and furnace pressure. My most specific reference is to the latter set of conditions, since these are the chief concern of the system of regulation with which I am most familiar. In passing I would say that methods of automatic reversal in accordance with regenerator temperatures or with a time cycle have relieved the crew of an unnecessary labor, have made possible the operation of a furnace under more favorable circumstances than with hand reversal, and have afforded an indication of disturbed and unequal conditions at the opposite ends of a reversing furnace. These systems have, therefore, proven their value.

The control of maximum roof temperature, which is now practical by two methods varying in detail, is of comparatively recent origin and is finding favor with furnace experts. In my judgment this form of control is a fore runner of a continuous fuel control which will operate during those stages of the process in which the rapidity of working is determined by the heat withstanding abilities of the refractories. The effect of any failure of such a control operation is so serious that thorough development and trial require to be made before the furnace can be turned over to it. Nevertheless, I believe that a comparatively short time will suffice for this purpose, and that such a control will in the near future come into general use.

Control of Fuel Flow

It is an elementary fact that the primary regulation in the case of any metallurgical furnace is that of rate of fuel use. Such regulation has always been practiced, generally by manual setting of a valve in the fuel line. The first application of automatic control to this situation is that of regulating pressure in the fuel line. With such an automatic regulation, the maintenance of an approximately uniform rate of fuel flow is easily possible. This flow will be regulated by valve position rather than by metering action of the control. It is always possible to

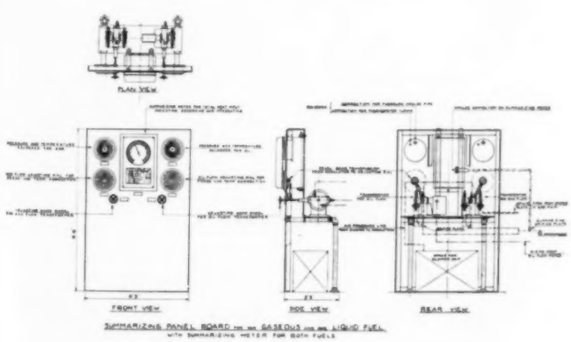

FIG. 7.

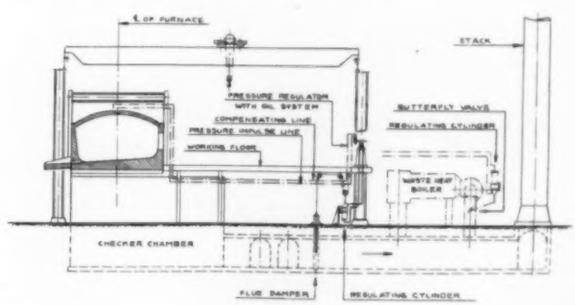

FIG. 9.

regulate flow manually in accordance with the reading of a meter. However, experience seems to indicate quite positively that there is an advantage in setting a control instrument in terms of standard units of flow since the operator thereby becomes accustomed to measure his performance by comparison with a definite rate of fuel use over a given time. Opinion may differ as to the value of this method. I think that people who have used it prefer it to the position regulation to which I have referred, on account of the fact that it results in a more carefully adjusted use of fuel than does the other method.

The regulating device required for this adjustment is that of a means of balancing a metering force derived from the flow against a definite counterbalancing force. Practically, this means the opposing of the differential pressure due to the fuel flow by the pressure of a spring or by a weight. The advantage of such a system of flow control is not only in the ease with which the operator is enabled to think in terms of standard units but also the ease with which variations in pressure and temperature may be compensated, so that the fuel is admitted to the furnace at a definite rate in terms of weight.

In Figure 1, which is a typical arrangement for furnace control, we show at the right the flow control arranged for a single gaseous fuel. The flow is metered by means of an orifice in the fuel line, the differential pressure being transmitted to either side of the regulator diaphragm. The flow is set by means of the hand wheel for flow adjustment which is provided with a scale. This setting should be checked with the reading of a flow meter from month to month, since the setting, while practical for operating purposes is not permanently accurate. The zero point may be readily adjusted if necessary at these monthly check-ups.

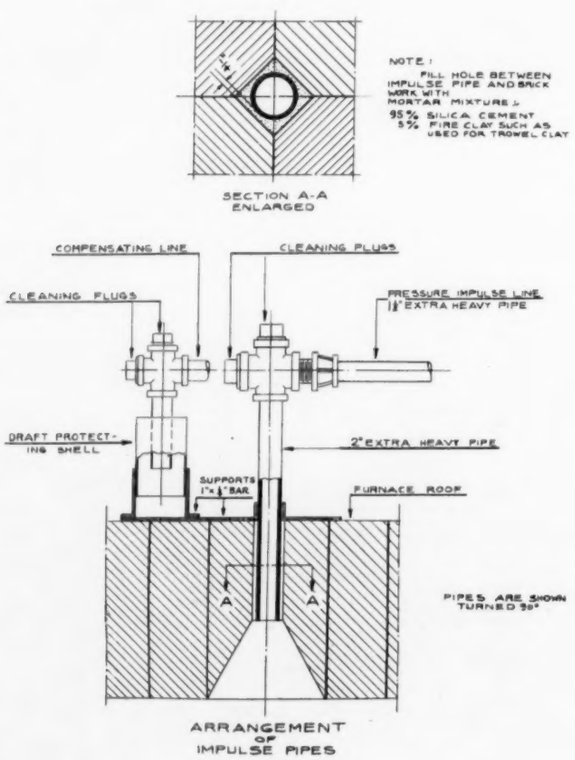

FIG. 10.

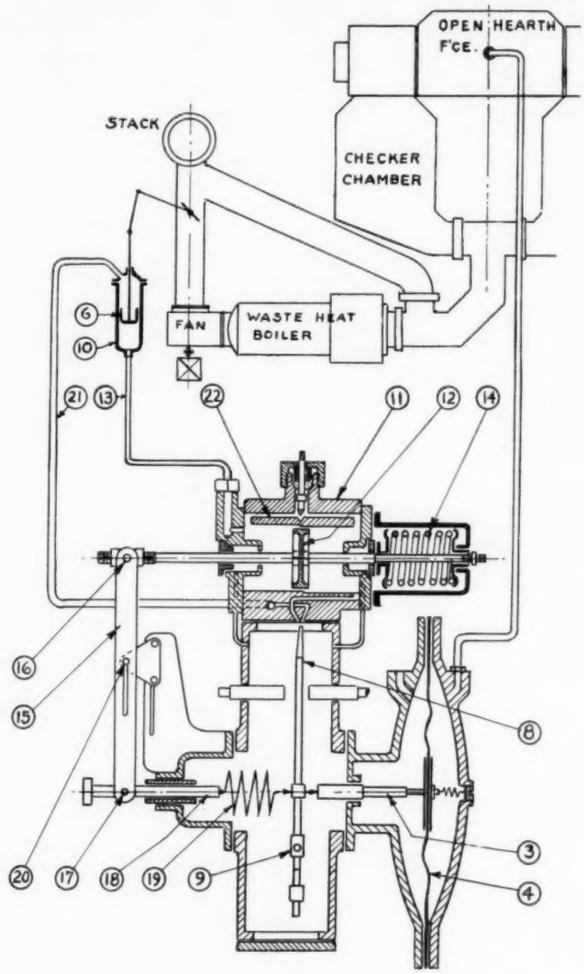

FIG. 11.

In addition to the flow adjustment, the regulator carries a hand wheel for temperature correction, with graduations on a dial. This wheel may be set from hour to hour in accordance with the indication of a thermometer in the gas line. Fuel gas is usually introduced at low pressure and in such cases pressure correction may be neglected. If the pressure is high enough so that its neglect involves a serious error, correction may be made as shown in Figure 2. This figure shows a revolving dial operated from the right side hand wheel. Temperature curves are platted on the dial and pressures on the stationary graduated vertical scale. It is necessary for the operator to read temperature and pressure and to move the dial so that the proper temperature curve crosses the right pressure line. The operation is quite simple to one with any knowledge of instruments, but it requires a man of some general education as well as special training to make its use thoroughly practical. As an instrument it presents no difficulties.

Flow of Liquid Fuel

This flow may be measured by a meter in the oil line and its flow regulated as before. Metering devices which we have used include the Brown area type flow meter operating in conjunction with the device shown at the right of Figure 3. This arrangement transmits to the regulator the pressure due to volume of flow. The figure shows the regulator arranged for furnishing an air supply in proportion to oil. Substitution of the spring setting for the diaphragm enables this regulator to be used to determine a constant flow. An alternative arrangement is shown in Figure 4, which is arranged for a metering impulse from an orifice in the oil line and which consists of a metallic diaphragm between sylphons, the office of the latter being to avoid a stuffing box and consequent friction.

Regulation of Producer Gas

Regulation of producer gas, with the arrangement of producers commonly in use requires a regulation of the producer itself. Figure 5 shows an arrangement whereby a predetermined rate of gas generation is set by means of the master regulator "M". The master impulse serves to determine the rate of parallel flow of air to the producers. Other features of gas producer regulation may include fuel feed and steam supply. A very satisfactory method has been found to be the regulation of continuity of coal feed in accordance with the gas temperature, with a manual adjustment of the rate of feed during charging periods, whereby the height of coal in the producers is kept in adjustment.

Regulation of Two Flows in Accordance With a Desired Total Heat Input

In many plants use is made of a combination of coke oven tar and coke oven gas. The proportions of these fuels may be advantageously changed during the progress of the heat. Occasionally a shortage of gas occurs, and it is desirable to replace the heat value of such a shortage with the liquid fuel. Such a replacement requires to be done automatically if it is to be done at all. Figure 6 illustrates the means which may be employed for this purpose. The regulating units shown at the left are air operated and serve to create a differential pressure across the small orifices which balance the main flow. These main flows are metered, by orifice and diaphragm in the case of the gas, and either by diaphragm or by means of a metering system based on the Brown area type flow meter in the case of the oil or tar. In the event the area flow meter is used, a specially shaped orifice is employed. This orifice is parabolic in shape and results in transmission to the regulator of a regulating force which varies as the square of the flow. The system is then in complete harmony so that all measuring relations are of the second power. The differential pressures created by the air flow from the left side regulators bear a definite relation to the main flow. They are summarized by means of the summarizing orifice on the right, the differential pressure across this orifice corresponding

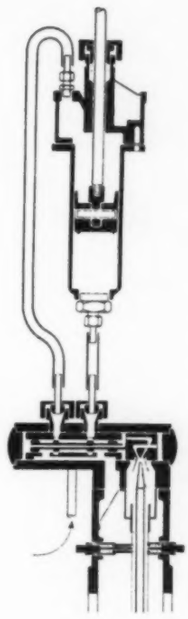

FIG. 12.

to the total heat in all the flows. The figure shows one constant pressure regulator with a spring setting which balances the air flow through the summarizing orifice. This regulator is used to regulate the oil or tar flow and will increase or decrease this flow as may be necessary to give a constant total flow of heat units.

Combustion air for the two fuels is furnished by one motor and fan, with no error other than that involved in the assumption that carbon and hydrogen require the same air per unit of heat value, an assumption, which, under all the circumstances, is nearly correct. In Figure 7 we present a view of a summarizing panel. This operates in conjunction with a total heat panel section shown in Figure 8. The arrangements for metering fuel flow to the regulators which are here shown are merely typical. A practical system of regulation of flows requires that the regulator shall work in conjunction with any static or differential pressures which the economics of fuel transmission and compression may make desirable, and a variety of metering systems are accordingly necessary.

Furnace Pressure Regulation

Regulation of static pressure is nominally the simplest of all regulating performances. As applied to metallurgical furnaces, however, there are practical requirements which demand of the designer more than merely pressure regulation. The accuracy which is desirable is within the limits of 1/100 inch of water column. There is considerable lag in the gas system of an open hearth furnace with a cor-

FIG. 13.

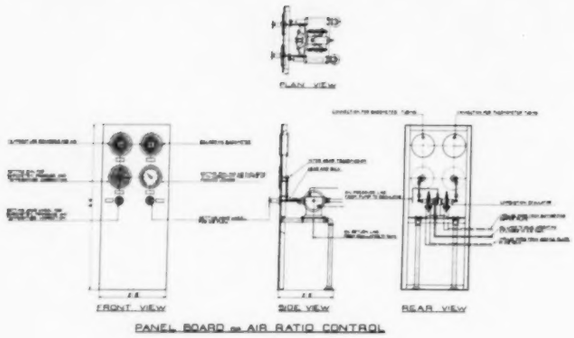

FIG. 14.

responding disposition to over regulate. There is in many cases the necessity of regulating by means of a damper, which weighs a ton, with four hundred pounds of unbalanced weight. This damper should be very accurately controlled, while at the same time means should be provided for rapid opening if the operator desires. The regulator should also be independent of very considerable temperature changes. Certain features of pressure control are exhibited in the accompanying figures.

Figure 9 shows a cross section through an open hearth and illustrates alternative possible means of regulating by flue damper or butterfly valve. Of chief interest is the double line of piping shown from furnace to regulator. The purpose of this is to eliminate stack effect in the vertical runs of pipe, which might otherwise involve an error of 2/100 or even 3/100 inches of water, out of a total pressure of, say 7/100 inches at the furnace roof.

Figure 10 shows detail at the furnace roof which has been successfully employed.

Figure 11 shows a constant pressure stabilizing piston used in conjunction with the regulator. This device operates to delay the regulating action, until the sufficiency of an initial change can be determined. It is applied to balanced regulating valves.

Figure 12 shows in diagrammatic form a piston valve operated by the regulating element, the purpose of which is very greatly to increase the pressure as well as the oil supply to the operating piston.

Figure 13 shows means whereby the damper may be temporarily opened to facilitate work within the furnace. The thumb screw and slide permit the regulator to open the damper without in any way interfering with its permanent setting.

The primary purpose of pressure regulation is to assure a removal of gases from the furnace at the same rate at which they are formed. Accomplishment of this object results in avoidance of quick changes in the size and shape of the flame and of undesirable impingement of the flame on the brick work. Prevention of air infiltration is a secondary object, and many pressure regulators are performing useful service even though set to maintain a sub-atmospheric pressure in the lower parts of the furnace.

Air Control or Combustion Control

In general this phase of control deals with the air supply for burning the fuel. There are several conceptions as to how this should be done. Among these is the method of regulating in accordance with a sample of gas from the furnace atmosphere taken after combustion is complete. This conception is academically correct and represents a fully automatic control. It is subject to lag and to certain difficulties connected with sampling, which will, in all probability, be overcome. Another conception is manual adjustment of two flows in proportion to each other. This involves a task for the furnace operator, that of calculation or observation of flows, which it is hard for him to perform promptly and satisfactorily. A third method, that of regulation of flow of air in accordance with a regulator setting which varies with the flow of fuel. This is generally called ratio regulation, and while open to some objections it is thoroughly practical and quite simple. It is shown diagrammatically on Figure 1. The differential pressure which measures fuel flow is used as a setting for the regulator which determines the air flow. This type of regulation, generally speaking, requires a fan to blow the combustion air. The fan has certain advantages aside from its application to automatic regulation of combustion air. An unregulated open hearth tends to lower its pressure between reversals as the ingoing checkers cool off and the outgoing checkers get hot. This process tends to increase the flow of air to the furnace, and to equalize the rate of operation between reversals. Automatic pressure regulation neutralizes this effect and in the absence of fan air tends to progressively reduce the air delivery between reversals. The use of the fan promotes uniformity in this respect.

Ratio regulation of combustion air is only practicable where leakage has been reduced to a minimum by insulation or otherwise. It is also subject to inaccuracies of varying pressure and temperature of air and of gas. These may be corrected by the means already suggested and shown in Figure 14. The power required for blowing is very slight on account of the temperature of the regenerators and the very low pressure required. A fan which has been successfully used in shown in Figure 15.

Detail of Control Equipment

In this brief statement I have endeavored to give an impression of the variety of practical conditions which require to be met, in metallurgical furnace regulation. These illustrate in some degree why untried or incompletely developed methods and equipment cannot be completely satisfactory, as well as

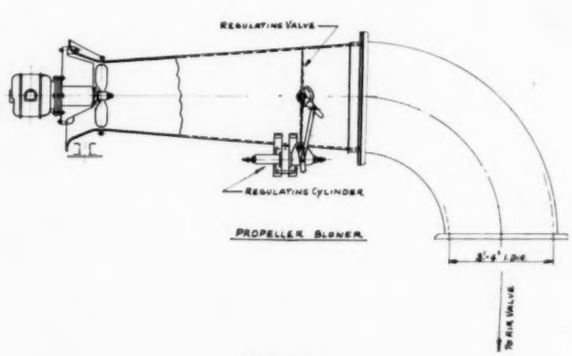

FIG. 15.

the number and variety of designs which require to be perfected before problems which are apparently simple are satisfactorilly solved. One purpose which I hope to have fulfilled is to indicate some of the reasons why regulating equipment is not a commodity, nor even a standardized technical product. In some degree almost all installations require modification or further development of existing designs. It is important that the engineering fraternity realize the extent to which this is true, and also, if the designers and suppliers are to serve their clients and customers to the best advantage, how little relation there is between the manufacturing cost and the total cost of such equipment as I have discussed. Regulation which is really worthy of the name is an engineering service, and no other kind is of any service at all, as applied to metallurgical furnaces.

Economic Results

The number of opportunities that have been afforded to evaluate the effect of well regulated furnace conditions is small and the conditions of isolation of the effect of control from that of other factors of practice are not satisfactory. We have reason to believe that with skilled operation, ten per cent of open hearth fuel may be saved, with attendant economies in increased tonnage and lowered repair cost. In steel heating furnaces there is an undetermined but considerable fuel saving and an ability to control furnace atmosphere which makes possible a better determination of the quantity and quality of scale.

I believe that the application of automatic control processes is unlikely to continue to be regarded as requiring separate evaluation, but that it will take its place along with substantial construction, good refractories, skilfully designed ports, regenerators and other furnace parts, carefully selected raw materials and accurate recording instruments in the hands of an intelligent and well trained personnel to produce a result which will be thoroughly satisfactory. In obtaining such a result I feel sure that automatic control equipment of the best possible design and liberally used, will play an important and indispensible part.

Discussion

Discussion presented by

M. J. Bradley, Engineer, Leeds & Northrup Company, Philadelphia, Pa.
G. M. Coughlin, Combustion Engineer, American Rolling Mill Company, Ashland, Ky.
M. J. Conway, Fuel Engineer, Lukens Steel Company, Coatesville, Pa.
E. W. Trexler, Supt. of Steam and Combustion Depts., Bethlehem Steel Company, Johnstown, Pa.
G. Fox, Vice President, Freyn Engineering Company, Chicago, Ill.

M. J. Bradley: I enjoyed Mr. Boynton's paper very much. It deals with a subject which is important in the steel industry and many points were brought out which are worth repeating. Obviously, it is desirable to have a good furnace system on which to apply automatic control if the best results are to be obtained. In other words, if automatic control be installed on an "Old Pot" (using shop terms) the results are not comparable with those to be obtained on a modernized furnace. Control equipment, in itself, is not capable of producing steel but is only a working tool or a means for the operator to maintain the most efficient operating conditions on the furnace. It should tie together in a definite relationship the variables in temperature, furnace pressure, stack draft, air-fuel volumes, etc., etc. The operator may change these relationships to obtain the conditions he desires to maintain on the furnace during any operating stage. However, he is assured that the conditions which he sets will be maintained until such time as he again changes them. It is desirable to have in addition to the control units sufficient recording meters, gages and temperature recording instruments to furnish accurate data on performance of the control equipments so that correct information may be obtained to definitely evaluate the results. In other words, definite figures should be available at all times rather than mere opinions on performance. Sometimes opinions are passed along in guise of facts, while in reality they may be very far from representing the true results.

Furnace pressure control by regulating automatically the stack damper from the furnace pressure is recommended by practically all open hearth superintendents. Such control, not only changes the position of the stack damper for each change in fuel supply but what is more important it maintains definite pressure conditions within the furnace preventing cold air infiltration. In effect it plugs the leaks and assures that the air used for combustion passes through the checker chambers where it is preheated for combustion. Approximately a 15% saving in fuel is realized for each increase of 200° F. in the temperature of the combustion air (after a temperature of 2000° F. has been reached). The furnace pressure above the bath should be maintained slightly above atmospheric in order to prevent cold air entering the wickets and around the doors. The cold air lowers the average temperature of the preheated air for combustions and thus slows down the combustion rate resulting in a lower flame temperature and waste of fuel. To illustrate, it is possible to burn 4000 cu. ft. of natural gas with the correct amount of cold air and impinge the flame on a cold surface and produce carbon black. In fact, this is a commercial method for making carbon black. However, by preheating the air for combustion in order to speed up the combustion rate, it is possible to make one ton of steel in an open hearth furnace with 4000 cu. ft. of natural gas. Automatic reversing actuated from the temperature conditions within the furnace system assures the maximum temperature of preheated combustion air and maintains the preheat cycle uniform on both ends of the furnace.

Furnace pressure control stabilizes the position and shape of the flame and maintains the heat heads or zones. In fact by preventing air infiltration it makes possible the successful operation of metered fuel-air ratio or combustion control. The latter ties the fuel and combustion air supply in a definite relation. This assures that when the operator in-

creases or decreases the fuel the air supply is automatically increased or decreased in proportion. This permits the furnace atmospheric conditions to be maintained and eliminates the excess air which carries the heat from the furnace up the stack.

The remark is often heard in these discussions that furnace control equipment requires maintenance attention. Certainly in order to get the best results from any control equipment we should expect it to receive some attention. Control equipment will continue to operate just as any other kind of equipment, but we should expect it to be checked and possibly changes in settings from time to time in order to function most efficiently on a furnace which gradually becomes less efficient as it gets older. It is not difficult for the operators to learn how to use the control to meet their requirements but it is desirable to have the control checked and settings changed by a control maintenance man who knows exactly what the control is supposed to do and how it does it. He must know when it is working most efficiently, and how to change the settings in order to obtain the best operation for the working conditions. This man should be technically trained, capable of interrupting the performance records and adjusting the control settings. He should be responsible for the maintenance and the operation of the control equipment. This suggests a control department and why not? It would be impossible to get along without the combustion department, the electrical department, etc., etc. As more and more control equipment is being added a control department becomes a necessity. We believe that such a department is justified at the present time in the majority of the steel plants.

Furnace control equipment has passed through the experimental stage. It is a necessity for quality production with fuel efficiency. Not so long ago it was considered rather good open hearth practice to be able to produce steel at 30 gallons of oil or roughly 4,300,000 B.T.U. per ton. We believe by the more complete use of control equipment and improvement in furnace design and construction it is now possible to produce a better quality of steel using around 20 gallons of oil or approximately 3,000,000 B.T.U. per ton.

G. M. Coughlin: As Mr. Boynton has said, you have to have good furnaces in order to make the control work properly. You have to make your furnaces good in order to make them work right whether you have controls or not. We have a slogan about safety: "Do what you know to do for safety," and I think that slogan could be applied to operations too—do what you know to do.

The question of automatic control has been developed mostly on open hearth practice, but it applies all the way down through the mill. Our line happens to be steel sheets, and one of the greatest problems is uniformity. It is necessary for us to make one sheet just like the next one on a particular order and you can't do that to the best of your ability unless you do have some kind of control. A difference of 50 degrees in one of the slabs coming out of the slab heating unit will make a difference. A difference of 50 degrees through the normalizer would make a nice mess too. Every sheet has to be just like the other one.

M. J. Conway: Those of us who have had open hearth furnace control in operation several years recognize the burden this control places upon us. It is generally realized that anywhere from three full controls up, together with the usual complement of instruments, that it requires the constant services of an instrument maintenance man. However, the expenditure on this maintenance is justified when we realize that it is liquidated by the saving of a fraction of a gallon of oil per ton of ingots made in a shop producing 500 tons per day.

We are too prone to take the line of least resistance and economize on this upkeep expense; thereby, not only lowering the net value of the control investment but also losing the saving that the control was designed to make, by neglecting to maintain its effectiveness.

Stack draft control is not effective unless the furnace is absolutely tight. One thing that insulation is doing by cutting down air infiltration is helping the efficiency of draft control. We have only started to improve open hearth furnace practice. May I congratulate Mr. Boynton on his excellent paper.

E. W. Trexler: I agree with Mr. Conway. There is considerable maintenance necessary on open hearth controls and it is necessary to have a competent mechanic take care of them or results will not be satisfactory.

Open hearth control, especially draft control, reduces fuel consumption and if properly installed should pay for itself in one furnace campaign.

G. Fox: The Russians are very much interested in the subject of automatic control. The so-called "Standard" 150-ton stationary open hearth, which is being widely adopted, is designed and constructed with a view to eventual use of automatic control; for instance, the regenerators are encased to minimize leakage, a blower with adjustable speed drive is provided to supply forced draft, etc.

The first furnaces to go into operation at Kuznetsk plant were equipped with a German (Junkers) make of air-gas ratio control and one was equipped with heat-input control.

At the time we severed our connection with the Russian work, about a year ago, a few of the new furnaces were getting into service. However, neither the furnace practice nor plant operating conditions had yet become stabilized to a point adaptable to the best use of automatic control.

So far as I am aware, no definite type of control has been generally adopted nor has any substantial experience yet been acquired which can contribute to this meeting.

Theory and Practice of Immersion Heating With Gaseous Fuels

By E. B. DUNKAK,
Vice President of the C. M. Kemp Mfg. Co.,
Baltimore, Md.

Paper presented at the A. I. & S. E. E. Annual Convention held in Cleveland, Ohio, September 18, 19 and 20, 1934.

Before proceeding with the discussion as to application of immersion heating, it might be well to consider the fundamentals of heat application to the external heating of salt and metal baths so that we can clearly understand why immersion heating has proved so successful in a wide range of applications.

The following will hold true for almost all plant installations of container heating equipment.

A—Heat transfer is limited by the surface of the container, and thus where high through-put is desired, container surface may be totally inadequate to transfer the required heat without excessively high furnace temperatures, which, in themselves, mean rapid deterioration of container and brick work and high stack temperatures with attendant heat losses.

B—The distribution of heat must necessarily depend upon, first—the degree of distribution obtained in the combustion chamber, and secondly on the ability of the mass in the container to transfer heat. Wide temperature variaton in the combustion chamber due to improperly located or insufficient burners and improper venting naturally means unequal heat distribution to the container; thus, while a recording and controlling instrument will often show satisfactory regulation, temperature distribution throughout the mass will be so unequal that rejects and spoilage will occur.

C—Attendant upon the use of an external combustion chamber come radiation losses of increasing importance, depending on the temperature of the operation. And finally, there is the almost always present infiltration of air, which, especially under low load or temperature holding conditions, extracts an appreciable quantity of the heat stored in the brick work, with a resultant lowering of thermal efficiency.

Thus, it is apparent that there are three basic principles involved in external heating, which can be materially improved. To sum up:

1. Heating surface
2. Heat distribution in the mass
3. Radiation losses.

E. B. DUNKAK

It was, in giving consideration to the possibilities of improving the overall efficiency of such heating operations, that members of our organization developed the principle which is now generally well-known under the term of immersion heating.

As early as 1916 experimental installations were made in solder baths and other small heating appliances, and it was as a result of these applications that the original Kemp and Van Horn patents were issued.

Over a period of years, progress of the art was slow but sure, and today, after four years of concentrated effort, the entire process has been reduced to its fundamentals, which, after all extraneous matter has been deleted, are relatively simple.

If you will keep in mind the disadvantages attendant to external heating, and then consider the theory of application of internal heating, it will be apparent how this method of heat application has overcome all of the disadvantages of the old.

In the design of immersion heating equipment for any specific operation, the following seven factors must be considered:

1. Maximum hourly B.t.u. requirement
2. Minimum hourly B.t.u. requirement
3. Temperature of operation
4. Material to be heated.
5. Form of heating element
6. Location of element
7. Burner application

However, before all this, it is first necessary to have the fuel under complete control, for we know of no heating application that calls for closer regulation of air-gas ratio than this.

In our work, we have found complete premixing of air and gas by automatic means to be indispensable. This method of combustion automatically assures an air-gas ratio that is not only carrying with it sufficient air for complete combustion so that there is no possibility of smothering the flame, but in addition will limit the air content so that maximum CO_2 is secured.

Further, it places the combustible fuel mixture under a positive pressure which permits high B.t.u. liberation per square inch of burner surface and assures a mixture flow against back pressures and in the absence of draft.

A further advantage is the homogeneous mixing of the properly proportioned air and gas. This assures rapid combustion in the space allocated for same in element design.

To attempt immersion heating without complete control over the fuel puts an insurmountable handicap on the operation. Complete premixing is essential.

Maximum heating requirements will largely determine the size of the heating element, although as later outlined, this is not entirely the controlling factor. Through experimental work and the results of several hundred installations, the hourly permissible B.t.u. input per square inch of heat transfer surface has been determined.

For almost all operations we have standardized on an allowable temperature differential of 100 deg. Fahr. between the working temperature of the operation and the exiting flue gases. This temperature differential has proved very practical as it permits the design of heating elements the displacement of which is not excessive and at the same time assure high thermal efficiency.

It would, of course, be possible to design heating elements to bring flue gas temperature down to the temperature of the operation, but for the slight efficiency to be gained (approximately 2.8% at 700 deg. Fahr.), the additional space occupied by the heating elements and the cost of the additional heating elements would not be warranted.

The factors for heat transfer naturally vary with the thermal conductivity of the material being heated, as well as the composition of the heating element and its wall structure. But as an indication of the high heat transfer obtained with low temperature differential, note the factor of 157 B.t.u. per square inch of outside heating element surface per hour, when transmitting through a 3/16" steel wall to molten lead, using coke oven gas as fuel, this with a temperature differential of 100 deg. between exiting gases and the molten lead.

Minimum heating requirements are determined by the heat losses under no-load condition. While not a factor in the design of the elements, the minimum heat requirement is a very important consideration in the design of the burner nozzle, as this must be able to function at a rate of flow well below the minimum heating requirements without backfiring.

The temperature of the operation influences the selection of the material from which the heating element is made, as does the material being heated. For example—with lead and type metals, it is satisfactory to use steel, whereas with tin, especially in the presence of a zinc chloride flux, special alloy cast iron is required. At higher temperatures, for example, lead heat treating baths, it is necessary to go to corrosion resisting alloys such as 18-8 and high chromium.

The form of the heating element is influenced by several factors which include the shape of the container and permanent internal obstructions such as pumps, drawoff valves, and passage for the work being handled.

The use of the recirculating continuous passage structure which permits the high velocity flame to entrain a portion of the cool products of combustion and thus reduce temperature in the flame zone has proved very satisfactory in eliminating local overheating on the surface of the element, and resultant deterioration. Early attempts, utilizing a heating element which is substantially a "U" in form, soon showed unequal stress and lack of uniformity of heat liberation.

The use of the recirculating element is not limited to any particular shape. For example, the elements are built to conform to the side walls of hemispherical pots or merely of rectangular shape to be disposed on the bottom of a square straight sided container. Right angle bends increase heat liberation but are not essential if the element is designed with sufficient heat transfer surface.

The location and number of heating elements employed to a large measure determine temperature distribution in the bath.

For example, it is usually desirable to provide greater heating surface at the inlet, with a decreasing amount of heating surface distributed through the bath to the outlet end. Thus, it is usually possible by judicious application of the elements to obtain any type of temperature gradient desired. In addition, the elements should be located in a manner that provides minimum interference with the work. The application of burners to the heating elements is a problem that has required a great deal of study and is, incidentally, by no means completed. The design of a satisfactory burner is such that it should be able to meet minimum and maximum heating requirements without change in flame characteristics or possibility of backfire. In addition, the burner should be compact and easily removable from the heating element for replacement. Burners are available which meet these rquirements.

Of particular importance in the design of immersion heating equipment is the necessity of providing portability to the heating element. It should not become a permanent portion of the container, for with immersion heating almost invariably the container life will be measured in terms of many years, while the heating element which bears the brunt of the heat transfer service is the portion of the equipment which will eventually wear out; and, although through the use of proper materials and correct design, element life is lengthy, provision should be made for its ultimate replacement

The advantages of immersion heating in actual practice vary with the type of the operation, and while all installations do not have all of the following advantages, in general, these may be summarized as follows:

a. Fuel economy
b. Temperature regulation
c. Heat distribution
d. Dross reduction
e. Increased container life
f. Improved working conditions
g. Increased production

Fuel economy is the most impressive immediate advantage, although in terms of dollars and cents, other factors may be of greater ultimate importance. Prominent among the several reasons for fuel econo-

my is complete premixing—which assures complete combustion without the presence of excess air or permitting the production of carbon monoxide.

A typical analysis of an immersion melting installation using artificial gas as fuel would show 13.5% CO_2, 0.0% CO, and 0.4%O_2. It is possible to maintain like analyses month-in and month-out regardless of the number of units in operation or the rate at which the units are being fired.

The heating elements provide adequate heat transfer surface. No longer need heating surface be limited to the exterior area of a pot or container. Where it is necessary, heating surface which is double that of the exterior container surface can be built into the elements; in short, the heating surface actually required to perform a given operation with a predetermined efficiency is built into the job.

With existing external heating practice, to my knowledge no attempt has been made to correlate the heating surface of the container with the work to be done, and as a consequence, when an installation is pressed for production, stack temperatures rise rapidly, with a corresponding reduction in thermal efficiency.

As previously outlined, because of high velocity of gas circulation, the heat transfer per square inch of heating element is high, and thus the total amount of heating surface required is not excessive.

Through the elimination of the external combustion chamber, with temperatures always higher than the temperature of the operation, side wall radiation becomes an almost negligible factor. Insulation efficiency as high as 94% is obtainable in actual practice. In addition, there is a very important economy effected when the pot is operated at low load or when its contents are at the predetermined optimum temperature and the firing equipment is turned down to low load.

Under like conditions, with external practice, air currents filter into the combustion chamber extracting heat from both brick work and container. With immersion melting practice this condition cannot exist since the outside combustion chamber is entirely eliminated, while a positive pressure is maintained in the interior of the heating elements, regardlesss of rate of flow. The effect of these factors is a reduction of 35% to 70% in fuel consumption as contrasted with external practice. A good average figure which immersion heating can almost invariably meet is 40% economy.

One of the most impressive things about any immersion heating installation is the remarkably close temperature regulation which is secured. As you well know, accuracy of temperature control depends upon much more than accuracy of the controlling instrument. The most accurate temperature control will not hold a metal bath at constant temperature if the heating equipment lacks capacity to bring heat recovery rapidly or fails to permit low turn-down when the pot is idling.

How immersion heating cares for these and other variable factors to produce close temperature regulation is shown in the following:

There is no heat absorption in a combustion chamber brick work.

In external firing, when fuel input ceases, the heat still continues to flow into the container from the overtemperature brickwork, thus causing temperature overrun. Conversely, when there is a demand for temperature increase, and the burner equipment again comes into play, there is a heat absorption by the brickwork which delays heat transfer through the container to the mass.

With immersion melting, on the other hand, there is virtually no stored heat, for that usually present in overheated brickwork and container is eliminated. The only portions of the apparatus which are at a temperature higher than that desired for pot contents are the elements themselves. For example, in a 20-ton lead melting pot, the total weight of the elements is 800 pounds. The maximum temperature differential between the elements and the lead at times of maxium gas input is 105°F., as shown by flue gas readings. The total stored heat in the elements above the temperature of the lead amounts to 12,800 B.T.U.'s which is no more than that liberated by the combustion of 24 cu. ft. of artificial gas. This shows clearly how overrun is eliminated. Conversely, when there is a call for temperature, no time or temperature is lost in heating these elements up to a point where heat flow again commences.

Heat distribution through the length and width and depth of the container is remarkably uniform and can be accounted for by the distribution of the heating elements through the mass and the ability to locate the heating elements where the heating load takes place.

In addition, the heating elements set up a thermal circulation of the bath contents which further minimizes temperature differentials.

Dross formation, which forms such a large portion of the cost of heating in many processes is materially reduced by utilizing an outstanding advantage of immersion heating. This is the blanketing of the surface of the molten metal with the substantially inert products of complete combustion. These contain less than 1% of the oxygen ordinarly present in the air, and on almost all installations, it is convenient to vent the heating elements directly over the surface of the molten bath, and through the ingenious use of hoods maintain a slight positive pressure which excludes surrounding atmosphere. Incidentally, the products of combustion being at a higher temperature than the molten metal impart some heat and thus partially counteract surface radiation.

There are three reasons why immersion heating brings with its economy on containers. In new installations the container can usually be fabricated at much lower cost than a similar unit designed for external firing because it does not have to perform the dual role of heat transfer medium and container. Also, the entire outside surface of the container can be supported. But most important is the fact that the container itself is never exposed to the deleterious action of uncontrolled flames or to temperature shocks. For low temperature melting operations where chemical corrosion is not present, container life can be said to be virtually everlasting with immersion heating.

Operations which in the past have been very objectionable from the standpoint of working conditions have been immeasurably improved through the elimination of external combustion chambers and the substitution of an insulated casing. On one low temperature installation, room temperatures were dropped 22 deg. by such an installation. In addition, the

equipment operates without exposed flame or noise, and the possibility of producing carbon monoxide is most remote.

So many heat processing operations are limited in production by the inability of the bath to maintain temperature or to recover temperature on the introduction of a load, that it can be said almost invariably that immersion heating increases production. There are many examples bearing out this point.

So much for the general aspects of immersion heating. To get down to cases permit me to sketch immersion heating accomplishments in the following specific operations:

1. Tinplate manufacture.
2. Stereotype melting (in newspaper plants.)
3. Can manufacture (side-seaming.)
4. Heat treating in a salt bath.

1. Tinplate Manufacture

A number of installations have been made in several prominent tinplate mills. The following data is typical of one.

Using 64" and 75" tin pots of welded steel construction modified to permit the installation of two alloy cast iron heating elements on the inlet end, each heating element having a connected load of 500 cu. ft. of 970 B.t.u. gas per hour operating under full automatic temperature control, gas consumptions as low as 18 cu. ft. per base box are being recorded daily, with production running 300 base boxes per 8-hour turn. Recording temperature control shows a maximum variation of plus or minus 2½ deg. F. in the tin and plus or minus 1 deg. F. in the palm oil. Dross formation averages 45# per 96 operating hours.

Contrast this with the previous installation which was representative of external practice. Gas consumption averaged 42 cu. ft. per base box, or two and one-third times as much. Temperatures varied six times as much, or 15 deg. plus or minus in the tin. Dross formation averaged 180# per 96 hours, or four times as much, and production was limited to a maximum of 260 boxes per 8-hour turn, or 13 per cent less.

2. Stereotype Melting

The use of immersion heating for the operation of stereotype pots used in newspaper plants is a good example of volume production at high casting rates. For example, an 8-ton stereotype pot actually has about 6½ tons capacity when immersion heating elements and pumping equipment are in place. Such a unit is called upon to cast 16,000# of stereotype metal (lead-antimony-tin-alloy) in one hour at a temperature of 610 deg. F.

With external gas such a casting rate cannot be secured without a material drop in temperature, but with immersion heating, temperature is not only maintained during the run but at any break temperature control frequently shuts the burners down to their pilots.

The connected load on such a unit is but 1,600 cu. ft. of 525 B.t.u. gas per hour, or 800 cu. ft. of 1050 B.t.u natural gas per hour.

Thermal efficiency runs well above 50%.

Our experience with more than eighty similar installations shows fuel economies ranging from 40 to 73%.

3. Can Manufacture

A good example of the ability of immersion heating to maintain the proper temperature gradient throughout a bath through which material is being passed is in the automatic side seaming of tin cans. In these units production in excess of 300 cans per minute is obtained, and to assure proper solder wiping as well as freedom from leakers, a temperature differential of 15 deg. is desired between inlet and outlet ends of the bath.

A properly designed immersion heating element assures this. While reducing gas consumption from approximately 190 cu. ft. per hour to 92 cu. ft. in terms of 525 B.t.u. gas, temperature is controlled by two thermostatic elements located in this portion of the bath.

4. Heat Treating in Salt Bath

Heat treating in a salt bath has been carried on successfully with immersion heating. Here we have an excellent example of increased production due to the ability of the heating elements to transmit a far greater amount of heat than side walls of the container.

Time cycle was so materially decreased that production was increased 60% over the old method, and inasmuch as standby losses are an important part of such a high temperature operation, fuel consumption per ton of wire produced was reduced by 50%.

Whereas pot life in the past was measured in terms of weeks, with immersion heating it can be measured in terms of months, if not years.

The immersion heating elements, to withstand the temperatures, must of necessity be of alloy steel if long life is desired.

The future for immersion melting holds great possibilities in a wide range of application, but the speed at which these applications are developed depends, in a large measure, on the co-operation that organizations such as ours receive from industry.

There are many operations that need improvement, but the co-operation of the plant management is invariably essential; for aside from half a dozen standardized applications, most installations involve at least some speculation as to results that will be obtained.

I have heard of no operation which is more in need of heating improvement than hot galvanizing, and there is undoubtedly an excellent opportunity for a co-operative effort between the immersion heating equipment manufacturer and the galvanizing plant.

Another field wherein heating problems are very apparent is heat treating in lead and salt baths, particularly at hardening temperatures. Here again is an opportunity for a co-operative development.

Our experience with approximately 300 installations in a wide range of industries has convinced us that immersion heating with gaseous fuel is destined for a widespread utilization, and it seems obvious that this is a subject that can be given profitable consideration by the industries concerned.

Discussion

Discussion presented by

G. M. Coughlin, Combustion Engineer, American Rolling Mill Company, Ashland, Ky.
E. B. Dunkak, Vice President, The C. M. Kemp Mfg. Co., Baltimore, Md.
M. J. Conway, Fuel Engineer, Lukens Steel Company, Coatesville, Pa.
J. H. Strassberger, Steam Engineer, Weirton Steel Company, Weirton, W. Va.
H. V. Flagg, Combustion Engineer, American Rolling Mill Company, Middletown, Ohio.

G. M. Coughlin: I would like to ask the speaker if he has seriously considered the application to sheet galvanizing.

E. B. Dunkak: I think you would have the same condition there as in tinplate manufacturing. In the standard tin pot there is no room for the immersion heating elements, but by making a slight change in pot design, they can be accommodated.

I presume in a sheet galvanizing kettle the elements would have to be provided for in a similar way.

Our particular worry in galvanizing is corrosion from the outside of the heating element. In tinplate manufacture the molten tin does not affect the cast iron element. As I understand it, the old cast iron tin pots were never affected by internal corrosion from tin but burned through from the outside.

M. J. Conway: Will Mr. Dunkak tell me if he has had any experience using his elements on large pickling baths?

E. B. Dunkak: We have done some work with immersion solution heating but not pickling baths as you know them in your industry. This would not present such a problem providing the material for the heating element stands up.

J. H. Strassberger: The author's paper was quite complete, and the only question I might ask on tin pot operation is this: what life do you expect from the heating elements?

E. B. Dunkak: Everlasting is a long time, isn't it? The original elements are still in service and show no sign of failure.

In the first place, we have controlled combustion atmosphere on the inside of the heating elements, and in the second place there is no local heating to develop high temperature zones which in tin would cause deterioration.

The life of heating elements has an important bearing on the economy the equipment effects. In other words, the equipment will make certain definite economies, but we can't waste all of these economies in element replacement.

While we have made a few small attempts on zinc melting, most galvanizing operations call for a rather large single installation—somewhat larger than we have attempted to try out all on our own. At least, that has been the case thus far.

We are open to any sort of a co-operative plan that a representative company might offer, and we certainly would like to sit down with their engineers and discuss that subject in detail.

M. J. Conway: I have another question to ask Mr. Dunkak.

How is the gaseous fuel and air proportioned before being fed to the heating element? Is a mixing machine used for this purpose?

E. B. Dunkak: We happen to be manufacturers of air-gas proportioning equipment termed the industrial carburetor. Its function, briefly, is to proportion air and gas by reducing them to the same pressure and entraining through adjustable orifices, compressing the mixture of gases in a turbo-type compressor and passing the resultant mixture, which has been homogeneously mixed by the action of the compressor, through backfire preventing equipment which safeguards this air-gas mixture which is in itself completely combustible. It requires no further air to be mixed at the burner, and thus we have the air-gas mixture under complete control both as to air-gas ratio and pressure.

H. V. Flagg: I would like to ask about the temperature gradiant throughout the heating element.

E. B. Dunkak: The gradiant isn't large. The burner size in relation to the internal bore of the heating element is purposely kept down to below 40% of its diameter, and by using this complete air-gas mixture under pressure, combustion takes place at very high velocities. Just beyond the flame zone the temperature has been materially reduced by the recirculation of spent products of combustion. The net result is that if you attempt to read temperatures on the surface of the heating element immersed in lead, you can't read any different temperature on any part of the element.

H. V. Flagg: I am familiar with what happens in conventional galvanizing pots with flame temperature gases on one side of the pot and molten spelter on the other, and there is a question in my mind what will happen to an element with undiluted burning gases on one side of the element and the molten zinc on the other?

In answer to Mr. Dunkak's appeal for co-operation from galvanizing plants for application of immersion heating to galvanizing kettles, picture the position of a combustion engineer who must approach his management with a request for some five thousand dollars to spend on a scheme which, however attractive the possibilities may appear, is still undeveloped and revolutionary. In these days when steel companies find it necessary to keep close check on expenditures of money, any proposal to revolutionize a heating process so well stabilized as that of galvanizing, must undergo close scrutiny. While I am in sympathy with Mr. Dunkak's position, I must stress the difficulties to be faced in working out the scheme he proposes.

E. B. Dunkak: I would say to you that the galvanizing kettle is too much of a proposition for us to take solely on our own shoulders. We must have some co-operation. By co-operation I don't mean that you buy the equipment and pay for it whether it works or not. I would say ordinarily that if this job is to be a practicable success on galvanizing kettles, we would have to develop heating elements, the material of which is available at relatively low cost.

The industrial carburetor is a standard item with our company. We make and sell them all the time. That cost of the job we could assume. What we need more than anything else from a manufacturer of galvanizing sheets is for him to turn over to us

that piece of equipment with the understanding that this is to be an experiment through and through, and if it does not work the first time, it is not to be dropped but continued efforts are to be made until the thing is licked.

H. V. Flagg: Have you any idea as to the mamaterial used for elements?

E. B. Dunkak: We have many ideas, of course, but whether or not they are good ones is another thing. I think we could get by with steel plate fabricated in element form, provided the proportions of element and burner are such that there is control of temperature over the entire surface of the element and no one point at which the element becomes excessively hot.

There is a temperature beyond which you cannot go, whether you internally or externally heat the kettle; and if that point is not exceeded, you can be assured of some degree of life.

Our thought has been for some time to not only control the temperature of the galvanizing kettle but to limit the maximum temperature to which the heating element can go; and, knowing the maximum allowable temperature, I think we can hold down rapid deterioration of the element. Would that be easier to put across?

H. V. Flagg: Do you think it would be possible to design an element that could be withdrawn and replaced by another one, say within five minutes' time, so it wouldn't be necessary to shut down while replacing elements?

E. B. Dunkak: First of all, you must have more space in the front of the pot than the pot provides. We would not heat a galvanizing kettle with but one element; it would probably require four.

Furthermore, I would not say you could take an element out in five minutes' time because they are rather awkward to handle.

G. M. Coughlin: I have often heard that the human mind goes from the complex to the simple. I think the author is a little complex. I would like to ask him if an element couldn't be fixed up with a cooling system on it? And couldn't this experimental work be carried on in Baltimore by merely heating up a container in order to determine whether or not the elements would live under those conditions?

E. B. Dunkak: We have done something along that line, but I don't think we have learned a thing. What we would be doing in that pot would be melting zinc and holding it at temperature. I think we would be missing the reaction that takes place when you pass a large amount of steel through the pot creating zinc-iron dross. This apparently has the most destructive effect on the pot.

ITEMS OF INTEREST

PERSONNEL CHANGES

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W. A. Hauck has been appointed Assistant to the President of Lukens Steel Company, Coatesville, Pa. He is a graduate of Lafayette College with the degree of mining engineer and was formerly Assistant Comptroller of Bethlehem Steel Corporation. Subsequently, he was connected with George W. Goethals, Inc., in company management and engineering work, and was also associated for several years with a New York stock exchange firm in underwriting and reorganization work. Prior to joining Lukens, he was with the American Iron and Steel Institute, engaged in work in connection with the Code of the Iron and Steel Industry.

▲

It has been announced by the Youngstown Sheet and Tube Company, Youngstown, Ohio, that J. S. Stanier, formerly superintendent of sheet mills, Brier Hill Division, has been promoted to the superintendent of the new cold strip mill department. Before joining the company in 1933 Mr. Stanier had been assistant to vice president in charge of operations of the Newton Steel Company and previous to that he had been assistant to general manager of the West Penn Steel Company, now part of the Allegheny Steel Company.

▲

Thomas R. Langan, who is well known in the transportation world because of his important engineering and commercial activities in the fields of railroad and railway electrification, has been appointed Traffic Manager of the Westinghouse Electric & Manufacturing Company, with headquarters in the East Pittsburgh Works. The appointment was announced by T. J. Pace, Westinghouse executive, to whom Mr. Langan will report.

▲

The American Sheet and Tin Plate Company, Frick Building, Pittsburgh, Pa., announce the following changes in the personnel of the Operating Departments and Executive Offices:

Mr. H. L. Bodwell, Manager of Vandergrift, Pa., Works, has been appointed Assistant Chief Engineer.

Mr. S. M. Jenks, Power Engineer, has been appointed Assistant Chief Engineer, succeeding Mr. J. A. Hunter, who will assume the duties of Power Engineer.

Mr. W. Guy Hoffman has been appointed Assistant to Chief Engineer.

Mr. W. T. Hugus, Assistant Manager of Gary Tin Mill, has been appointed Assistant to Vice President.

Mr. W. L. Goodhue, Manager of the Farrell-Mercer Works, has been appointed Manager of Vandergrift Works, succeeding Mr. H. L. Bodwell, who was appointed Assistant Chief Engineer.

Mr. C. A. Ferguson has been appointed Manager of Farrell-Mercer Works.

Mr. H. S. Pyle has been appointed Assistant Manager of Farrell-Mercer Works.

Mr. L. B. Landon has been appointed Manager of

Gary Tin Mill, succeeding Mr. Thomas O'Brien, who voluntarily retires.

Mr. C. R. Bottenfield has been appointed Assistant Manager of the Gary Tin Mill.

Mr. C. E. Miller, Jr., has been appointed Assistant Manager of the Gary Tin Mill.

All of the above appointments were effective as of March First.

▲

John M. Mulholand, formerly special representative of railroad sales of The Youngstown Sheet & Tube Company, has recently been appointed manager of railroad sales for the company. Mr. Mulholand's headquarters will continue to be Chicago.

▲

SKF Industries, Inc., announce the opening of a new branch at 407 South Fourth Street, Minneapolis, Minn. Mr. A. Kishkunas is in charge.

The new office carries a complete stock of SKF ball and roller bearings, pillow blocks and hangers to meet the rapidly increasing demand for an overnight bearing service.

▲

The Carnegie Steel Company, Pittsburgh, Pa., announce the appointment of W. B. Weston as assistant to the vice president and general manager of sales. Before this promotion, Mr. Weston had been manager of sales in the Detroit district for subsidiary companies of the U. S. Steel Corporation.

WITH THE MANUFACTURERS

▲

The Trumbull Electric Mfg. Company, Plainville, Conn., announce the issuance of a manual describing the Trumbull Controlite—a control switchboard for stage and auditorium lighting. This 16-page manual gives a wealth of information of a general character in regard to stage and auditorium lighting. In addition to the engineering data with typical layouts this manual contains a complete glossary of stage lighting terms.

▲

The Illinois Steel Company has just issued a bulletin describing a new product called multigrip floor plate. From this bulletin it is learned that the design of the plate had been the result of long experimentation to assure the highest degree of skid resistance from every angle. Other features of this new plate are its comfort under foot, for while it offers a sure tread there are no sharp protuberances.

▲

Lukens Steel Company, Coatesville, Pa., announce the release of a booklet entitled "World's Largest Plate Mill and Its Products," which is a pictorial summary of the work of Lukens Steel Company and its divisions, By-Products Steel Corporation and Lukenweld, Inc.

▲

The first frequency changer in which are incorporated the advantages of operation in an atmosphere of hydrogen has been completed at the Schenectady works of the General Electric Company and will be installed at the Freemansburg, Pa., substation of the Pennsylvania Power and Light Corporation.

The new frequency changer will convert 60-cycle, three-phase power to 25-cycle, three-phase power for use at the Bethlehem Steel Company's plant at Bethlehem, Pa. The motor of the new set is a 24-pole, 12,000-volt, 300-rpm machine rated at 23,500 kva at 0.9 power factor. The generator has 10 poles, and at 6,900 volts, 0.9 power factor, will deliver 22,222 kva.

The use of hydrogen cooling in this new frequency changer is an outgrowth of the development of hydrogen-cooled synchronous condensers by General Electric during the last few years. Hydrogen is a more efficient cooling agent than air, permitting a saving in size for the same power rating. With hydrogen, the windage loss is about 10 per cent of that with air—this loss being nearly proportional to the density of the gas in which the machine operates. Electrically, the tendency for the formation of corona is eliminated by the use of hydrogen.

Hydrogen pressures of from one-half to one pound per square inch are maintained within the casing of the frequency changer by means of an automatic pressure regulator which takes make-up hydrogen, when required, from an auxiliary tank. It is necessary to hold only enough pressure to insure that any leakage which occurs will be outward, thus maintaining the purity of the hydrogen in which the machine runs.

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Answering the need for a low current arc welder capable of handling the lighter gauge metals used in auto bodies, etc., the Harnischfeger Corporation of Milwaukee has just announced a new P&H-Hansen 50-Ampere vertical model.

The outstanding feature of this new welder, known as the W50-254, is the extremely stable high speed arc which enables it to weld quickly and efficiently down to 26 gauge steels. No external reactors, resistors, or separate stabilizers are used; the self-stabilized arc is achieved through the use of an exclusive internal stabilizer winding. Being a motor generator unit with a 3HP squirrel cage motor, it operates on any alternating current power line including 110 volt single phase. With current control simplified to a single adjustment dial at the top of the housing, it is ideally suited for welding of ferrous and non-ferrous metals in general repair work or for the fabrication of containers of stainless steel, phosphor bronze, aluminum, etc., with the metallic arc.

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For use with the smaller capacity cranes of the monorail and crawler, gasoline or electrically-operated type as used in foundries, scrapyards, railway stores and maintenance of way departments and in warehouses, The Electric Controller & Mfg. Company, 2790 E. 79th St., Cleveland, Ohio, announce the new EC&M 25" diameter type RH lifting magnet.

This magnet is of new design throughout, with water-tight construction, both top and bottom, and a heavily ribbed magnet case to provide a very strong and durable magnet of excellent heat radiating capacity.

The coil is thoroughly insulated from the spool on which it is wound and after winding, is vacuum

impregnated with moisture-repelling compound. It is securely fastened in the case by welding around the inner and outer circumferences of the bottom plate, and the magnet case is then filled with compound to the top of the terminal block.

Each magnet is furnished complete with two heavy protected connecting cables and two quickly attachable, rubber covered cable connectors. For operating the magnet, the #00 automatic-discharge magnet controller, consisting of a small, but sturdy, two-position master switch and a steel safety cabinet containing the contactors and resistors, is provided.

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The Delta-Star Electric Company, Chicago, Illinois, have issued price list No. 38-B1 applying to group operated pole top, switches from 7.5 K.V. to 161 K.V.

Prices of steel mounting frames, cross arms and motor mechanisms are also included.

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Manufacturers and users of heavy duty direct current generators, motors and rotary converters will be interested in the announcement by the Carbon Sales Division of National Carbon Company, Cleveland, Ohio, of a new series of electrographitic brushes designed especially for service on heavy duty direct current equipment.

The company states that this new series of brushes is the product of a four-year program of research applied to the problem of determining the fundamental physical properties essential to satisfactory brush performance on heavy duty direct current equipment, the combinations of materials possessing these necessary properties, and exact methods of production control to insure uniformity in both product and performance.

The new series of brushes resulting from this program are to be known as the "SA" Series of National Pyramid Brushes. The series consists of five grades namely, SA-25, SA-30, SA-35, SA-40, and SA-45. An important item of technical interest in regard to these grades, is the stated fact that each grade of the series has a progressive relationship to the other grades with respect to commutating and mechanical characteristics, thereby making it possible to obtain longer brush life by selecting the combination of characteristics best adapted to the inherent characteristics of the machine and its service. The series, as a whole, covers an extremely wide range of applications.

A new trade mark identification has been established by National Carbon Company for the new "SA" Series. In addition to the now familiar trade marks, the Three Pyramids and the Silver Strand Cable, the new series will be further identified by the double engraved lines down the center of one side of the brush.

▲

A new hard surfacing electrode which is designed for building up straight carbon steel, low alloy or high mananese steel surfaces to resist abrasion is announced by The Lincoln Electric Company, Cleveland, Ohio.

This new electrode, known as "Abrasoweld", will be found of particular value in such applications as restoring teeth, lips and bottoms of power shovels; lugs and treads of tractors; housings and impellers of centrifugal sand pumps; rock crushing equipment; agricultural machinery; gear and pinion teeth.

"Abrasoweld" electrode provides a deposit of abrasion resisting alloy of the self hardening type which surface hardens very rapidly under conditions of impact and abrasion. This type of deposit has definite advantages over that which shows its maximum hardness as deposited. The tendency of the deposit to chip off in service is eliminated. Unlike that of other electrodes, the "Abrasoweld" deposit develops its maximum hardness only at the surface where it is cold worked. This leaves a strong tough core for resisting shock. In this respect, the "Abrasoweld" deposit is similar to high manganese steel, the only difference being that "Abrasoweld" metal is harder as deposited and increases in hardness much more rapidly. For example, moderate peening will increase hardness as deposited from 20-30 Rockwell C to approximately 50 Rockwell C. Weld metal produced by "Abrasoweld" must be ground to shape as it cannot be filed or machined.

Added to these advantages the "Abrasoweld" deposit is more resistant to corrosion than high manganese steel. The deposit can be forged hot without materially altering its physical properties.

"Abrasoweld" electrode is made in 3/16 inch size, 14 inches in length. It is used with reversed polarity with a current range of 125-200 amperes and 24-27 arc volts.

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J. S. Ervin, president of the Mackintosh-Hemphill Company, of Pittsburgh, announces that his company has received an order from the Inland Steel Company for construction of new blooming mill equipment for that company's Chicago plant.

This improvement in Inland's primary production facilities is one more step in a comprehensive program of modernization and development which already has covered a period of several years and involved the expenditure of many millions of dollars. Inland, which is one of the largest companies in the United States in ingot capacity, has been a growing factor in the Mid-West producing area, which has been gaining in size and importance in recent years. It is one of the major producers of sheet and strip steel, plates, bars, rails, structural shapes, as well as a long list of miscellaneous items.

Mr. Ervin announced that work will begin immediately on the Inland project, which is a 36-inch, two-high, reversible, electrically operated mill. This and other recent orders obtained by Mackintosh-Hemphill will provide additional and steadier employment for workers at the company's plants in Pittsburgh, Midland, Pa., and Wooster, Ohio.

The Inland order is the second large contract for mill construction announced by Mackintosh-Hemphill. Recently the company received the "go-ahead" on a new blooming mill for the Jones & Laughlin Steel Corporation, which is a part of that concern's $4,500,000 program for rebuilding its plant on the South Side, Pittsburgh.

▲

Amtorg Trading Corporation has just placed with the United Engineering & Foundry Company of Pittsburgh, Pa., for the Zaporojstal Steel Works

There Are Definite Reasons Why Buss Super-Lag Fuses Can Save You Money

The design of the BUSS fuse case is such that it helps eliminate poor contact. This feature gets right at the heart of most fuse troubles.

It is heat from poor contact that causes fuses to char and burn up—takes the temper out of fuse clips—raises the temperature of the link and causes fuses to blow before they should.

Such features as the contact making projection in the cap of the 3 to 60 ampere fuse or the automatic aligning of the terminals of the 70 to 600 ampere fuse are money saving features found exclusively in BUSS fuses.

Of course, BUSS Renewable Fuses have the SUPER-LAG Feature. It gives fuses a time-lag long enough to allow harmless overloads to have a chance to "clear themselves" without blowing the fuse. It eliminates many needless shutdowns.

These features are just a part of a design in which every detail has been shaped towards preventing the needless blowing of fuses.

If You Are Interested in Cutting Costs—

Fuses are not "just fuses".—Some are better than others. It will cost you nothing to find out why—just drop us a line today.

BUSSMANN MFG. CO., ST. LOUIS, MO.
A Division of the McGraw Electric Co.

BUSS FUSES

A. I. & S. E. E.—TWENTY-SEVEN YEARS OF ENGINEERING SERVICE TO THE IRON & STEEL INDUSTRY

ADVERTISING PAGES REMOVED

of the Soviet Union an order for an electrically driven steel rolling mill, to be erected at "Zaporojstal", U. S. S. R. This order, for more than $3,000,000, which is one of the largest of its kind ever placed in the United States for foreign shipment, covers steel rolling equipment in the new mill. The Zaporojstal Plant is designed to have a yearly capacity of 600,000 metric tons of hot and cold strip up to 60" wide for use in the rapidly expanding Soviet industrial program. A portion of the mill will be built in the U. S. S. R. to the detailed drawings and technical assistance to be furnished by the United Engineering and Foundry Company.

This mill, which will be similar in design to the one which United is now completing for the Ford Motor Company plant at River Rouge, Mich., will fit smoothly into the United production schedule, and will be completed and shipped within 15 months.

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The Louis Allis Co. of Milwaukee, Wisconsin, publish regularly every other month a 24-page company magazine for those interested in the purchase or maintenance of electric motors.

This magazine is attractively printed in colors and not only contains engineering data and technical articles on electric motors and other equipment but also contains articles of general interest.

Copy of this interesting 24-page magazine will be sent with the company's compliments.

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A system for providing mobile electric circuits for portable tools so that work can be followed along conveyor and assembly lines without the use of long, unwieldy and dangerous cords and cables, has been introduced by the Switch & Panel Division, Square D Company, Detroit, Mich.

The system is known as Trolley Square-Duct and consists of an almost entirely closed duct containing stationary busses, along which travels a carriage or trolley. Collector wheels of the trolley transmit the current by means of wire connectors to the tools.

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The Timken Roller Bearing Co., Canton, Ohio, has just received one of the largest single orders for steel mill bearings ever placed. This is in connection with the new Zaporojstal steel mill recently ordered for the U. S. S. R. by the Amtorg Trading Corp., from the United Engineering & Foundry Co.

Timken Bearings will be used on the roll necks of the back-up and work rolls of the 4-high 24"x49"x 66" hot strip mill, the back-up roll necks of the 19" and 49"x66" tandem cold strip mill and the 16"x49"x 42" reversing cold strip mill, as well as on the 20½" and 56"x84" single stand reversing cold mill and the 2-high 27"x56" cold skin pass mills and the 16" and 48"x66" cold sheet planishing mill. In addition to the main roll neck bearings, Timken will also furnish anti-friction bearings for use on the tables and table drives, screw downs, gear drives, coilers and uncoilers, pinion stands, etc.

It is estimated that approximately 1500 Timken Bearings, weighing approximately 200 tons, will be used in this Russian mill . These bearings specified by the U. S. S. R. engineers after an extended study of American rolling mill equipment and practice, will range in weight from one pound up to nearly 4 tons apiece. A single one of these big bearings contains enough steel to put Timken Bearings on over 900 popular price cars.

A. I. & S. E. E.
COMING MEETINGS AND PAPERS

PHILADELPHIA SECTION

L. F. Coffin, Chairman — L. O. Morrow, Secretary
Engineer's Club, 1317 Spruce Street
Dinner 6:00 P. M. — Meeting 7:00 P. M.
April 6, 1935

"Electrolytic Pickling of Steel and Coating of Metals," by G. B. Hogaboom, Engineer, Hanson-Van Winkle-Munning Company, Mattawan, N. J.

"Bethanizing-Electrolytic Coating of Zinc on Wire," by F. O. Schnure, Superintendent Electrical Department, Bethlehem Steel Company, Sparrows Point, Md.

CHICAGO SECTION

C. J. Smith, Chairman — A. J. Whitcomb, Secretary
Electric Association, 20 North Wacker Drive
April 3, 1935
Dinner 6:30 P. M. — Meeting 7:45 P. M.

ELECTRONIC SHOW

This meeting is a joint one with the electrical maintenance engineers, and will comprise lectures and demonstrations of electronic tubes and allied equipment. An exhibit of the new cathode ray oscilloscope will be in operation and will show the rise and fall of a current or sound wave. In addition, there will be shown many applications of the electric eye. Preceding the electronic show there will be two discussions presented by H. D. Sandborn of the General Electric Company and A. J. Germain of the Westinghouse Electric & Mfg. Company.

PITTSBURGH SECTION

H. G. R. Bennett, Chairman — C. H. Hunt, Secretary
Blue Room, William Penn Hotel — March 23, 1935
7:30 P. M.

"Anti-Friction Bearings for Roll Necks and Auxiliary Mill Equipment," by G. Palmgren, Chief Engineer, SKF Industries, Inc., Philadelphia, Pa.

OBITUARY

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Robert Goss Wells, Vice President, The Steel Company of Canada, Hamilton, Ont., died February 22. Mr. Well's steel mill career was as follows:

Member of Engineering Department, Illinois Steel Company, 1894-96; Chief Draftsman, Nicopol-Mariopol Mining and Metallurgical Company, Mariopol, Russia, 1896-1899; appointed Resident Engineer, Dominion Iron & Steel Company, Sydney, N. S., 1899-1901; Engineer of Construction, Otto-Hoffman Coke Company, New York City, 1901-1906; Superintendent, Struthers Plant, Youngstown Sheet & Tube Company, Youngstown, Ohio, 1906-1908; appointed General Manager, Tata Iron and Steel Company, Jamshedpur, India, 1908-1913; joined The Steel Company of Canada, Ltd., as Works Manager, 1913; appointed Vice President, 1926.